STANDARDS DEVELOPMENT BRANCH OMOE
3 6936 00000 2443

POLLUTION CONTROL AND ENVIRONMENTAL HEALTH

May 17, 1979

PROCEEDINGS

Organized by:

Pollution Control Association of Ontario

Ontario Ministry of the Environment

TD
172.5
.P65
1979
MOE

Date Due

TD
172.5
.P65
1979

Proceedings of the seminar on pollution control and environmental health /

5109

TD
172.5
P65
1979

POLLUTION CONTROL ASSOCIATION OF ONTARIO

and the

ONTARIO MINISTRY OF THE ENVIRONMENT

PROCEEDINGS

of the

Seminar on

POLLUTION CONTROL AND ENVIRONMENTAL HEALTH

held at the
Ontario Ministry of Health Laboratories
Resources Road, Toronto

MAY 17, 1979

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact Service Ontario Publications at copyright@ontario.ca

C O N T E N T S

	Page
Occupational Health - Current Priorities Dr. E. Mastromatteo, Director, Occupational Health, Inco Limited, Toronto	1
Toxic Substance Management in the Workplace H.M.Nelson, Occupational Health Branch, Ontario Ministry of the Environment	25
The Canadian Centre for Occupational Health and Safety Dr. F.H. Hicks, Planning Secretariat, Canadian Centre for Occupational Health and Safety	37
Air Pollution from Industrial and Municipal Operations C.B. Martin, Ontario Ministry of the Environment	45
Environmental Health as a Factor in Design T.A. Constantine, M.M. Dillon Limited, London	57
Development of Canada's Drinking Water Guidelines V. Douglas, Health & Welfare, Canada	73
Wastewater Disinfection - A Multifaceted Problem G. Victor Buxton, Environment Canada	89
Sewage Effluent - Is Disinfection Necessary? Ann H. Vajdic, Water Technology Section, Ontario Ministry of the Environment	101

OCCUPATIONAL HEALTH - CURRENT PRIORITIES

by Dr. Ernest Mastromatteo,
Director, Occupational Health,
Inco Limited, Toronto, Ontario

Occupational health problems occupy the increasing attention of governments, workers, and employers across Canada. Before reviewing the current priorities it is important to note that job hazards have been recognized from the time of the first hunter, the first fisherman, the first farmer, and the first miner.

Hippocrates, the father of medicine, who lived in ancient Greece, first drew attention to the environmental factors in the causation of disease.

Ramazzini, a professor of medicine of Padua in Italy, is regarded as the father of occupational medicine. He wrote a book on occupational diseases in 1700. Ramazzini described silicosis in miners, hearing loss from exposure to noise, paralysis in lead workers, and emotional diseases in pigment workers handling mercury. Ramazzini gave sound advice to the physicians of his day - he suggested that they ask one more question of their patients: "What is your job?"

Even occupational cancer - considered a problem of today's technology - is not a new phenomenon. Sir Percival Pott in 1775 first described cancer of the skin of the forearm and scrotum in chimney sweeps exposed to coal tars in their work. Thus, occupational cancer has been recognized as an occupational risk in some groups for more than 200 years.

Dr. J. Rehn in Germany reported bladder cancer in chemical workers making aniline dyes. In 1895 he predicted that there would be a great increase in such cancers as a result of the widespread use of chemicals in industry - a prediction which did come true in his time.

In the decade of the 1970's there were many activities in the occupational health field. In 1970 the Occupational Safety and Health Act was passed in the United States and the Occupational Safety and Health Administration (OSHA) established in the Department of Labor. Two requirements under this U.S. legislation are noted:

Section 2(b) - "to provide for the general welfare, to assure so far as possible every man and woman in the nation safe and healthful working conditions ....."

Section 6(b) - provides for the establishment of permanent standards so that "no employee will suffer material impairment of health or functional capacity ..... for the period of his working life".

The 1970's have seen the publication of a number of popular and technical books in the United States and elsewhere describing the hazards and problems in the workplace.

The book "Work in America" grappled with the questions of job satisfaction and job stress. It quoted Albert Camus, as

follows: "Without work all life goes rotten. But when work is soulless, life stiffles and dies."

"Expendable Americans" by Paul Brodeur described the long-term hazards of asbestos. Brodeur spoke of the "harmless substances" which were "casually introduced into the workplace". Brodeur's book also referred to the estimates of up to 100,000 deaths per year in the U.S. from occupational diseases.

"Work Can Be Dangerous to Your Health" by Jeanne Stellman and Susan M. Daum, drew attention to the uncontrolled hazards in the workplace. This statement appears in their book:

> "Each day millions of workers in America enter a battlefield, but they fight no foreign enemy and conquer no lands. No borders are in dispute. The war they are fighting is against the poisonous chemicals they work with and the working conditions that place serious mental and physical stress upon them. The battlefield is the American workplace, and the casualties of this war are higher than those of any other in the nation's history."

"Help for the Working Wounded" by Thomas Mancuso was intended as a basic handbook for organized workers. The following statement appears in the introduction: "Millions of union members now work under conditions that jeopardize their health. The danger grows out of the ever-increasing use of chemicals spawned by this petrochemical age. These chemicals - some manmade - can and do cause serious damage to those who work with them. The working wounded are everywhere - in countless shops and factories". The underlined words provide the theme for the title of the book.

"Crisis in the Workplace: Occupational Disease and Injury" by Nicholas Ashford noted that society's major concerns in the 1970's were:

1) a concern for work and its meaning,
2) a concern for environmental quality, and
3) a concern for good health care, including access to preventive health care systems.

All of these concerns are focussed in the workplace and it was only natural that attention would be drawn to working conditions.

The vinyl chloride episode which came to public attention in 1974 raised questions of the insidious long-term hazards of many other substances in the workplace. Vinyl chloride had been used since the 1940's and it had been regarded to be of relatively low risk to workers exposed to it.

The decade of the 1970's has also seen a number of public inquiries into the hazards of the workplace, including the Robbens Commission in the United Kingdom, the creation of a National Board of Occupational Safety and Health in Sweden, the report of the Gale Commission in Alberta, the Ham Commission in Ontario, and the Beaudry Commission in Quebec. A White Paper on Occupational Safety and Health has been published in Quebec; this White Paper contains a number of important implications for change in occupational safety and health in the Province of Quebec.

The basic concepts in many of these Commission reports and inquiries are similar. They include:

1) The consolidation of occupational safety and health programs and resources into a single government agency.

2) The consolidation of occupational safety and health legislation into a comprehensive and consolidated Act.

3) The establishment of joint worker-management occupational safety and health committees.

4) The right of workers to be informed of hazards, to be trained, and to refuse work which may present an imminent hazard to health and well-being.

I welcome the current interest in occupational health. I hope this interest will be effectively channelled so that government, employers, organized labour and workers can work together to improve occupational safety and health for all workers in Canada.

With this quick overview of the developments in the decade of the 1970's, I will now review some of the priorities in the field of occupational health as I see them. It is presumptuous to attempt to predict the future trends and priorities in occupational health for the 1980's. I will, however, do so from my personal viewpoint, with particular application to mining activities where appropriate.

Kermit Lansner, Senior Consultant, Louis Harris and Associates, pointed out the difficulties in attempting to predict future trends. He did, however, speculate on some of the important issues of the 1980's. Lansner considered these issues as important ones for the 1980's:

1) Occupational health. He felt that the interest generated in occupational health in the 1970's would continue in the 1980's.

2) Inflation.

3) Unemployment.

4) Research. This concern dealt with the decreasing number of graduates in science and engineering in the United States compared to other countries and the reduction in research and development expenditures by government and private industry.

5) Energy shortage.

It is important to note that these issues do not exist in isolation - they are inter-related in their causation and effects.

Turning now to the field of occupational health, I will list some of the current priorities with recommendations for action to be considered. Again, I would like to stress that I am expressing my own personal viewpoint on these priorities.

Occupational Cancer

It is estimated that 2 in 5 people will get cancer and 1 in 5 will die of cancer. Cancer as a disease is universally dreaded. It evokes strong emotional feelings. As a disease, cancer is often fatal and irreversible.

Some years ago the International Agency for Research in Cancer (IARC), a division of the World Health Organization, estimated that 90 per cent of cancers are caused by exposure to environmental agents. Some persons have concluded that this 90 per cent refers entirely to chemicals in the workplace. This is not the case. The environmental agents cited in the IARC estimate include:

natural ultraviolet radiation from sunlight
personal diet
personal lifestyle, e.g., - cigarette smoking
- drugs
- alcohol
personal hygiene
natural background radiation
place of residence
and other factors.

In the case of lung cancer, it is estimated that 80 per cent of lung cancer and 30 per cent of all cancers in males is caused from cigarette smoking. Most of the occupational lung cancer reported has also been in workers who are cigarette smokers.

Higginson of IARC estimated that 1 to 5 per cent of cancers were due to occupational factors. Sir Richard Doll of U.K. and Ernest Wynder of U.S., both prominent biostatisticians, support the estimate of 1 to 5 per cent of occupational factors in cancer. This is a significant proportion and I would not wish to minimize the importance of occupational cancer. I would, however, like to put it in the perspective of all environmental cancers, including those attributable to personal factors such as cigarette smoking.

Since the recognition of coal tar as an occupational cancer by Pott in 1775, the following occupational carcinogens have been recognized:

(1) Skin cancer in workers exposed to: shale oil, creosote, arsenic, ionizing radiation, ultraviolet radiation, and petroleum cutting oils.

(2) Lung cancer in workers exposed to: certain nickel and chromium refining operations; mining, milling and use of asbestos; coal tars in coke oven workers; radon daughters in uranium mining, fluorospar mining and iron ore mining; and arsenic exposure in copper refining.

(3) Sinus cancer in workers exposed to: certain nickel refining operations, furniture makers exposed to certain hardwood dusts, and boot and shoe workers exposed to leather dust.

(4) Urinary bladder cancer in workers exposed to: certain rubber chemicals, e.g., betanaphthylamine, and to dye intermediates, e.g., benzidine.

(5) Leukemia in workers exposed to: benzene and ionizing radiation.

(6) Mesothelioma in workers exposed to asbestos.

(7) Angiosarcoma of the liver in workers exposed to vinyl chloride.

(8) Bone cancer in workers exposed to radioactive isotopes.

The current NIOSH Registry of Toxic Chemicals lists about 1,500 "suspect" carcinogens used in industry.

In the United States, OSHA has recently held hearings on a generic proposal to categorize and control occupational carcinogens. A substance which had been demonstrated as a human carcinogen or which had been demonstrated to cause cancer under experimental conditions in two animal species would be considered as a category one carcinogen and subjected to an emergency standard with strict requirements. These requirements include: a zero exposure limit standard (or the lowest reliably detectable limit), the insistence on engineering control measures in preference to the provision of personal protective measures, the installation of double locker systems, frequent environmental monitoring and health examination, and the maintenance of monitoring and worker health records by companies.

I believe it is important to closely watch these developments in the U.S. In fact, various companies and employer representatives have reacted sharply to the OSHA generic cancer proposal.

At the close of the generic cancer hearings in the United States, Mr. J. Califano, Secretary of the Department of Health, Education and Welfare, presented a paper entitled "Estimates of the Fraction of Cancers in the United States Related to Occupational Factors". In this paper the authors (drawn from the National Cancer Institute, the National Institute of Environmental Health Sciences, and the National Institute of Occupational Safety and Health) estimated that as much as 20 to 40 per cent of cancer was caused by occupational exposure. There have been a number of serious criticisms about this "estimates" paper. In the main, the paper has been criticized for using inflated numbers of workers believed to be at risk and for using high risk factors which were drawn from published studies of workers known to be at particularly high risk exposures. It is not likely that the last has been heard about this "estimates" paper.

There are two aspects about occupational cancer which I feel require special comment. These are:

1. The extrapolation of experimental data from animals to predict effects in humans. In some animal experiments very large doses of the chemical under

test are given to the animals. These large doses alter the usual metabolic pathways used by the animal in handling the chemical and the effects produced by such large doses may not be relevant to the effects in man exposed to much lower levels of the chemical. In some cases, cancers are produced by injection, implantation or other techniques which are not relevent to worker exposure, which occurs chiefly by inhalation and skin contact.

My personal view is that extrapolation of animal data is useful and applicable when due account is taken of such factors as species difference, dosage administered, metabolic differences between the experimental animal species and humans, the route of administration, and the health status of the experimental animal. Others hold to the view that animal data are relevant to human experience regardless of the dose level administered.

2. The concept of zero threshold in the response of carcinogens. In 1958 the U.S. Food and Drug Act was amended by the so-called Delaney Amendment. This amendment provided for a zero level in food for any food additive or food residue which was shown to cause cancer in experimental animals or in humans. While it is true that some effect may be noted at the low dose levels in the individual cell, I believe that a "practical" threshold exists for carcinogens. When

risks of lung cancer are expressed in terms of the number of cigarettes smoked per day and the number of years smoked, this is recognition of a "practical" dose-response effect. There is a strong body of opinion that zero thresholds should be established for chemical substances which are shown to be associated with increased risk of cancer in humans or which are found to cause cancer in experimental animals regardless of the dose levels given. There is much current interest in inorganic chemicals as carcinogens - arsenic, beryllium, nickel and chromium. With exposure to inorganic chemicals there has been a tendency to lump all compounds of the element as carcinogenic despite the fact that the human studies have been related to very specific types of exposure.

I rank occupational cancer as a very important priority for the 1980's. It is important that the issues raised above be addressed. There is need for research -

(1) Epidemiological research in exposed workers with information on the environmental exposures encountered.

(2) Experimental research in animals.

Other Chronic Diseases in Mining Occupations

Occupational cancer has been discussed separately above. Questions have frequently been raised about the relationship of long-term inhalation of low concentrations of dusts and respiratory irritants encountered in mining and refining operations to the subsequent development of chronic bronchitis. Similar questions have been raised about long-term low level exposure to carbon monoxide and heart disease; the relationship of job "stress" to such diseases as peptic ulcer or heart disease; and the relationship of repetitive movement on arthritis and back disorders.

These are important questions. It is important to know the answers if society is to fairly compensate the victims of such diseases and in order to take appropriate action to prevent such diseases.

One problem with occupational exposures is that there is seldom exposure to a single chemical substance or to a single environmental agent. Generally workers are exposed to a variety of agents which may exert synergistic, additive or antagonistic effects on the human body. Despite this difficulty there is a need to carry out long-term epidemiological studies of workers in an attempt to relate their health or disease status to the level and duration of exposure to particular agents on the job.

In order to carry out health studies the mining industry will require good records on job histories and environmental monitoring data. Much of the workplace monitoring is now switching to full shift personal sampling although there is still need for area monitoring. Companies must now investigate the need to switch to computerized employment history, medical history, and environmental exposure for each worker.

Epidemiological studies and monitoring surveillance are expensive and difficult for smaller mining companies to employ. Smaller companies may come together to share the expenses of such programs.

I believe that better use could be made of medicare and compensation data in carrying out health studies in relation to mining work.

It is important that negative studies be reported. In the past, only positive studies tended to get reported.

Health studies are important and necessary but they must be done in such a manner so as to protect the confidentiality of health information for individual workers. Individual health data should never be divulged but the results for groups of workers may be divulged.

Permissible Exposure Limits

Permissible exposure limits to airborne substances and to physical agents have been established in many countries. In North America, the threshold limit values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) are widely used. There are three types of listing in the ACGIH TLV list, as follows:

1) TLV - time-weighted average (TLV-TWA)
2) TLV - ceiling value (TLV-C)
3) TLV - short-term exposure limit (TLV-STEL).

TLVs were originally intended as guidelines for the control of occupational diseases. They are now used more and more in legal codes - a use for which they were not originally intended. Some occupational health specialists have been critical of the so-called "numbers game". Others, however, consider that the use of permissible exposure limits in legal codes is necessary for efficient enforcement.

My personal preference would be to use the most current TLVs as guides in Canada. Exposure limits for specific substances or agents could be modified for Canadian use on the basis of special circumstances or experience in Canada. Despite my personal preference, permissible exposure limits will be increasingly used in legal codes over the next decade. For this reason it is important that mining companies, industrial hygienists, safety specialists and others in the occupational safety and health field become

familiar with TLVs, their benefits and their limitations. The simple adoption of permissible exposure limits in legal codes is not, in itself, a guarantee of a safe and healthy work environment. Such limits require interpretation by those trained in the field of occupational health.

The Concept of Risk Assessment

No person can give an absolute guarantee of safety regarding exposure to any chemical substance or physical agent in the work environment. Zero risk means zero exposure. If certain goods or services are required for the good of society in Canada, then some level of occupational risk will be involved for the workers involved in producing the goods or services.

Some health risks are voluntarily accepted by individuals, e.g., in smoking cigarettes, in driving automobiles, in hunting and fishing, in athletic and sports activities, and in being overweight. Pochin in the United Kingdom has evaluated the risk of dying from certain common activities. His figures are of interest. He reported that the risk of dying is one in a million from the following activities:

smoking	1½ cigarettes
drinking	½ bottle of wine
travelling	50 miles by private car
travelling	250 miles by airplane
rock-climbing	for 1½ minutes

canoeing	for 6 minutes
doing "typical" factory work	for 7 to 14 days
being aged 60	for 20 minutes

The employer has the responsibility to ensure, as much as possible, that the workplace is safe and that workers are properly trained so that they can carry out their job safely. In arriving at "acceptable" occupational health risks as expressed by standards or guidelines of exposure, workers, employers and governments should all be aware of the nature and degree of the risks which are known and the control measures which are needed to overcome these risks.

The concept of risk acceptance must not be viewed as placing an economic value on human life and suffering but rather in deciding what social priorities have to be met for the good of society in general. It is of interest to note that some economists are also opposed to prohibiting all exposures to toxic substances.* The overall benefits from allowing exposure to some substances may indeed outweight the costs.

The recent final report of the U.S. Interagency Task Force on Workplace Safety and Health is of interest. This task force was set up by President Carter in August 1977 to consider ways and means to improve the U.S. Federal

---

* Paul Portney, Current Issues in U.S. Environmental Policy, Johns Hopkins University Press, 1978, p. 7

role in occupational safety and health. The task force concluded that OSHA's expectations were unrealistic and that better co-operation could be achieved among Federal agencies.

Screening of Chemicals Used in the Workplace

The demonstration of subtle health effects which have a long latent interval, e.g., those which cause cancer, has demonstrated the need for a better way of screening of chemicals before their use in the workplace. Because of the great number of chemicals currently in use, for which little toxicity data are available, and because of the introduction of many new chemicals each year, a system of rapid, effective and cheap pre-screening is needed. Conventional methods of toxicity testing in animals are slow and expensive - taking up to 2 years or more and costing from $200,000 to $750,000 per chemical to be tested.

In the last decade a number of *in vitro* short-term tests have been developed for assessing the possible mutagenic and carcinogenic effects of chemicals. Bacterial systems may be used (e.g., Ames Test), biochemical tests of DNA synthesis and repair, and cell transformation tests. Currently much consideration is being given to pre-testing involving a 3-tiered system. Pre-testing will provide some indication of the need to do more definitive testing as in lifetime animal studies.

The mining industry should be involved in the development of the agreed protocols to be used in screening and evaluating new chemicals in the workplace.

There is in Canada a general lack of toxicology and pre-screening facilities. In United States the chemical industry has joined together to set up a Chemical Industry Institute on Toxicology. There will be a need for such facilities in Canada. A Canada Centre for Occupational Safety and Health has been set up. It may play a role in this particular need in Canada.

Joint Worker-Employer Safety and Health Committees

As noted earlier, employers have the responsibility for ensuring a safe and healthy workplace but effective co-operation between workers, employers and government is needed. Joint occupational safety and health committees should function in a true participatory fashion to determine and correct the safety and health problems at the workplace. Those that cannot be resolved at the workplace by this joint committee should be resolved by the appropriate governmental inspectorate or by outside consultants.

Information and Documentation on Occupational Health

There is a lack of reliable data on the incidence and prevalence of occupational diseases in the mining industry. There is a need to develop a standardized system of defining,

collecting and publishing data on occupational injuries and diseases.

There is also need for a source of information in Canada about the toxicity and health hazards of chemical substances and agents encountered in the work environment. There are a number of computerized data bases in the United States, e.g., Toxicology Data Bank, Medline, Toxline, Cancerline, Chemline, etc. These can provide on-line information. It is expected that the new Canadian Centre for Occupational Safety and Health will play a major role in gathering Canadian statistics on occupational diseases and in providing information and documentation services in the field of occupational health.

Worker Education; Safety and Health Education of Miners

Over one-third of fatal injuries in U.S. mining operations involve miners with less than one year of experience on the job. The U.S. Secretary of Labor has promulgated mandatory training standards for occupational safety and health in miners. The training program must provide not less than 40 hours for new underground miners and 24 hours for surface workers or miners assigned to new jobs. Miners are also to receive 8 hours refresher training each year.

There are an estimated 212,000 coal miners in 5,700 coal mining companies and 275,000 non-coal miners in 1,500 mining companies in the U.S. The mandatory training

standards in the U.S. will require a major training effort. Training of miners has been required for over a decade in the United Kingdom. In the U.K. the National Coal Board operates 40 training centres and the basic training of new coal miners takes 100 days with an additional 40 days of supervised training at the coal face.

Workmen's Compensation and Class Action Suits

In the U.S. many class actions have been taken or are underway in which workers have sued for damages for not advising the workers of the health hazards in the materials used. In Tyler, Texas, 445 workers received a settlement of $20 million in a suit against two employers ($14 million); the U.S. Government ($5.7 million), which had inspected the factories and had not advised the workers of the hazards of asbestos; and the union ($.3 million). Currently there is a class action by 5,000 shipyard workers exposed to asbestos for $1 billion, and another by 15 workers exposed to lead for $100 million. A number of welders in U.S. have initiated action against welding suppliers alleging that exposure to metallic fumes resulted in neurological damage.

I am not sure whether such class actions could take place under Canadian law but this is a matter to be decided by lawyers. My point in raising the U.S. development is to reinforce the importance that employers, governments and suppliers are aware of known health hazards involved in the workplace and that the worker is advised of these.

In the field of workmen's compensation, there are many issues and developments but I shall deal with only one here. This relates to the concept of cumulative injury as pioneered in California. Cumulative injury refers to the cumulative injury produced by small daily job-related stresses on the body of the worker over his lifetime of work exposure. The succession of slight injuries, each in themselves not considered capable of causing disability, is believed capable of leading to a cumulative destructive effect on the body. Cumulative injury compensation benefits are being paid in California for such conditions as back pain, arthritis, heart disease, bronchitis, hypertension, and neuroses. In California, most claims are made at or near retirement whenever the worker is of the opinion that the health condition is related to cumulative injury on the job. Such claims are increasing at the rate of 20 to 25 per cent in California.

My purpose in describing cumulative injury as a compensable benefit is to bring this to the attention of Canadian mining companies. This development adds more significance to studies which relate health effects to specific job exposures.

Occupational Health in Mining - Some Special Points

Underground mining presents a number of health hazards. Exposure to pneumoconiosis-producing dusts is

still a major concern. Pneumoconiosis rates in mining have declined with improvements in dust control and health surveillance of miners but pneumoconiosis still remains as an important concern.

Noise also remains an important occupational health hazard in underground hardrock mining. Hearing conservation programs, which include determination of high noise work areas, pre-employment and periodic hearing testing in workers employed in noisy areas, noise control measures and the meaning of personal protective devices, should be adopted for noise exposures exceeding 85 dBA in mining operations.

There is a good deal of current interest in the health effects of exposure to diesel exhaust in underground mining. NIOSH has expressed concern that diesel exhaust particulates may be carcinogenic. Studies of miners and other workers exposed to diesel exhaust have not demonstrated any increased risk of lung cancer. The use of diesels in mines did not become widespread until the late 1950's and some consider that there has been an insufficient latent period to demonstrate increased risk of cancer. NIOSH has undertaken studies of coal miners and hardrock miners exposed to diesel exhaust. Experimental work in which animals are being exposed to diesel exhaust is underway. NIOSH in the U.S. has already taken action to restrict the use of diesel in coal mines.

Mining companies should be aware of the concern expressed by some concerning exposure to diesel exhaust. My own view is that diesel exhausts have not been demonstrated to cause cancer in humans.

Summary

I have attempted in this article to provide a general review of the main occupational health concerns in mining in Canada.

Occupational health will continue as one of the major concerns in society during the 1980's. A number of specific areas of concern stand out, including the assessment and control of workplace cancer hazards, the relationship of chronic diseases and "cumulative injury" to workplace exposures, the application and use of permissible exposure limits for environmental agents in the workplace, risk assessment in the workplace, screening of chemicals for use in the workplace, occupational health questions in the employment of women, worker education in occupational safety and health, and the use of diesels in underground mining.

Expenditures and resources for workplace monitoring and for the health surveillance of miners and for occupational health questions in general, will most likely have to be increased in the next decade.

TOXIC SUBSTANCE MANAGEMENT IN THE WORKPLACE

by: H.M. Nelson, P.Eng., Occupational Health Branch, Ontario Ministry of Labour

Before considering the subject of management of toxic substances in the workplace, it is important to examine some basic concepts that influence modes of action to be followed. Some considerations are:

1) Allowable Exposure Levels

There are many terms used to refer to a permitted or allowable exposure level. These terms include Occupational Exposure Limit (OEL), Maximum Allowable Concentration (MAC), Maximum Worksite Concentration (German MAK). In Ontario we have borrowed terms from the American Conference of Governmental Industrial Hygienists and refer to their Threshold Limit Values (TLV), as well as Time Weighted Average Exposure Limited (TWA). These terms, with perhaps the exception of MAC refer to average airborne concentrations of contaminants to which workers should be able to be exposed for normal work days and work weeks without suffering ill effects over a working lifetime.

Because they are average values, it should be possible to have excursions above the levels if there are corresponding periods below the levels. There are in most cases limiting values that should never be exceeded. In Ontario we use the terms, also from the American Conference of Governmental Industrial Hygienists, Short Term Exposure Limit and Ceiling Exposure Limit, to refer to these upper values.

The setting of these exposure levels depends on an important concept expressed by Paracelsus in 1538. He considered all substances were poisons depending on the dose administered. Conversely all substances can be tolerated if the dose is small enough. From the dose concept it follows that there must be some level or concentration that a person can tolerate by detoxifying it, excreting it or storing it. This no-effect level, if it can be determined, is used as the basis for setting allowable airborne concentrations for worker exposure. For some materials the toxicity is so high or incidental environmental exposures are so close to the no-effect level that, allowable, workplace exposures may be set at or close to zero.

2) Combined Effect of Multiple Exposure

It is seldom that a pure exposure to one toxic substance will be encountered in a workplace. Quite often though the hazard of one material present is so overriding that it becomes the basis of a control program. Thus, in a storage battery manufacturing facility much of the concern is directed to the lead hazard. However, when two or more exposures are present their combined effect may be -

a) unrelated
b) additive
c) synergistic or
d) combination may be so complex that control is based on an indicator, e.g., coke oven emissions, diesel exhaust and many metallurgical processes.

3) Route of Entry

There are three main routes of entry of any material into the body. They are -

1) Ingestion (swallowing)
2) Inhalation
3) Skin absorption or entry through cuts or wounds.

In addition, some chemicals have a corrosive action or are strong skin allergins.

4) Monitoring

Air sampling in the workplace can be used to achieve the following purposes:

a) Determine compliance with a standard or exposure level.
b) Determine a worker's exposure.
c) Determine effectiveness of control measures.

An air sampling program must be well planned using appropriate methods to meet its objective.

Toxic Substance Control

To apply a good control program, data must be available as to types of materials present, quantities, methods of use, processes, etc.

Finally, two further considerations before applying controls are -

1) Can the material(s) in question be replaced by a less hazardous material(s).
2) Controls should aim to keep concentrations as low as possible because:
   a) As already stated threshold limit values or allowable levels do not guarantee 100% protection. It follows that maintaining lower concentrations should provide a greater degree of protection.
   b) Probably more important, is the fact that there is always, in future years, the possibility that some subtle effect will be determined that is not presently recognized.

Having decided that the use of a certain material is necessary, that is substitution is not an option, and it is found a hazard exists or is likely to exist the control measures must be implemented. A general approach or philosophy of control or management would be as follows:

1) Reduce the level or concentration of material to the acceptable level or below by means of engineering controls.
2) Provide other measures, as necessary, to prevent re-exposure, ingestion, skin absorption or skin contact.
3) Where procedures, for any reason, fail to reduce concentrations below the acceptable level, then provide administrative controls. That is workers should be rotated or provided with relief so that by reducing their time in exposure the permissible time-weighted average may be met.

4) Where the above measures do not control exposures below the allowable exposure level or where for a temporary period, during which controls are being installed, exposures are above the limits then respiratory protection should be used.

Engineering Controls

Engineering control measures include, but are not limited to, the following:

1) Isolation

a) Where a process produces a hazardous emission it is possible to enclose it in order to prevent the escape of material, or conversely it may be possible to enclose or isolate the operator in a booth.

b) Where two or more sources of emissions are present which by themselves would not represent a hazard, it is possible these operations could be divided among shifts. For example, in a welding shop it may be possible for say six welders to work with no problem. If further welders are required to operate, it may make sense to put them on a second shift.

c) When a single operation presents a hazard and adequate control is not feasible, it may be possible to conduct the operation on an off shift and give personal protection to the small number of exposed operators. This has been applied successfully, for example, to spray painting of aircraft where ventilation was not efficient. By doing the spraying at night or weekends when repair workers were not present, the operators could be fitted with air-supplied hoods and protective clothing.

2) Material Handling or Processing

This includes automated closed operations as opposed to open batch type processing; materials moved by conveyor instead of by hand, wet processes which are less dusty than dry ones, brush painting rather than spray painting. For batch feeding it is possible to pump liquids to vessels rather than pour them and, sometimes it is possible to have exact weights of packages prepared for addition rather than scooping or dumping. There are no restrictions to the types of measures that might be employed.

3) Local Suppression

This includes wetting down of dusty materials either in process operations or to prevent dusting of piles of material or rubble. This is important in mining operations, scrap operations such as secondary lead refining, foundry work, etc.

Other types of local suppression are -

a) Use of surface active agents or plastic balls in plating oeprations.

b) Use of water on mercury or heavy chlorinated hydrocarbon solvent baths to prevent evaporation.

c) Covers placed on tanks and other containers, or directly on piles to prevent evaporation or dispersal of materials.

Imagination can be used to find other examples.

4) Ventilation

This is perhaps the most important control method used today or at any period in time.

Ventilation is described as the movement of air into and out of an area, room or building. The movement can be caused by either natural means, i.e. infiltration, stack effect, or wind or by mechanical means, i.e., fans or other types of air movers. There are some cases where significant air movement is achieved by the fact that air is removed through combustion.

Contaminant removal is achieved by local exhaust which collects the material at its source, preventing its escape to the general work area; or, by general ventilation which provides air exchange in the work area to dilute contaminants.

Examples of the various methods of exhaust ventilation are as follows:

a) Local Exhaust

(i) Natural Draft - The flue or chimney of most furnaces.

(ii) Mechanical - Paint spray booths, slot exhaust on a plating tank, grinding wheels, conveyor transfers, mixers and mills of various types.

b) General Exhaust

(i) Natural Air Exchange - Some welding shops, any source of low toxicity dust, fumes, etc. in small concentration.

(ii) Mechanical Ventilation (supply or exhaust of air or both) - high production welding shops, metal pouring operations.

The type of ventilation system used will depend on the type of contaminant to be controlled (its toxicity, volatility, form, etc.), the amount or concentration involved, the size or shape of building or workplace and economic factors. Normally a local exhaust system is more expensive to install than a general ventilation system, however, because it is more efficient less air is handled. Usually during cold weather replacement air must be heated. Sometimes the cost of heating the greater volumes of air handled in a general ventilation system is higher than the cost of the preferred local exhaust system.

Work Practices

These are measures that act as adjuncts to primary control measures to improve their effectiveness and to prevent secondary exposures to toxic materials. Some examples are:

1) Housekeeping: The purpose is to remove accumulations of materials to prevent them from becoming airborne. It includes:
   a) Cleaning of solid material on floors, rafters, machines and other surfaces to prevent redusting or breakdown to finer particles. Vacuum cleaning or wet cleaning are considered appropriate. Dry sweeping or blowing of dust are not recommended, although in at least one instance, blowing down of dust followed by sweeping was done on a weekend under carefully controlled conditions.

b) Cleanup of solvents, corrosive materials, mercury, etc., may require unique methods such as neutralizing, reaction to less toxic substances, dilution, etc. followed by conventional cleaning methods.

2) Maintenance

Any control system must be kept in good working order.

3) Personal Hygiene

Depending on the exposure and extent, personal hygiene requirements range from simple hand washing facilities up to double locker systems with showering facilities and clothing changes with laundry between uses. The more elaborate requirements are necessary with such exposures as asbestos, lead, mercury, many carcinogens, etc.

4) Training

If a worker is informed of the nature of any toxic materials to which he is exposed, then he is more likely to use the safeguards provided. A well trained worker because of his awareness is better prepared to accept the hazards than one not informed.

5) Labelling

Containers of toxic materials should be labelled in such a way as to indicate the hazard and indicate protective measures necessary.

6) Warning Notices

Signs can be placed in areas where hazardous materials are present, so that workers and visitors are aware of their presence.

Personal Protective Devices

Only as a last resort, on a temporary basis during installation of controls or as an adjunct to otherwise adequate controls should respirators be used. This is to say, respirators are not to be used as a substitute for good environmental controls. Where there is hazard from skin contact, protective clothing may be necessary.

Medical Surveillance

Even where good toxic substance control has been provided, in many cases, medical controls can be provided to -

a) avoid placing persons susceptible to an occupational disease in a risk exposure.
b) avoid placing unfit persons in exposures.
c) determine base line condition before entering exposure, and
d) regularly monitor the worker to determine the appearance of an occupational disease or any condition for which the worker would be ill advised to remain in exposure.

The physician is able to assess a person before employment for fitness to work and routinely thereafter for fitness to continue employment, or to assess the limitations to be placed on continued employment.

Conclusion

The management of toxic materials at work requires more from the employer than the measures already discussed. In addition, the following should be carried out:

1) Set up an inventory of materials used, amounts and processes they are used in. Keep the inventory up-to-date.

2) Determine the byproducts, waste products, etc., that are formed in the processes.
3) Find out the toxicity and hazard of materials present.
4) Determine first aid measures, protective clothing that may be necessary.
5) Outline proper work operations, practices to be avoided and control measures.
6) Maintain records of monitoring and medical surveillance records so that an exposure and medical profile of each worker is kept.

THE CANADIAN CENTRE FOR OCCUPATIONAL HEALTH AND SAFETY

by: F.H. Hicks, M.D., Planning Secretariat
Canadian Centre for Occupational Health and Safety, Ottawa

In the early years of this century, William Osler, the great Canadian physician, made this statement:

"It is the tragedy of today that man is so indifferent to the life of man. Yes, we surround the babe unborn with premonitory protection, deal wisely and gently with infancy and childhood, and then hurl the product of a reasonably healthy youth into a maelstrom of blind chances, of dust, fumes, and fatigue, which wear down the stoutest body and cripple the most willing worker."

If Osler was able to survey the current scene in Canada, he might well leave his statement unchanged. While individual Canadians have been working in the field and making significant contributions to occupational health and safety since Osler's day, the area has been low on the priority lists of governments, universities and health professionals. Canada, for example is only now setting up a national centre for occupational health and safety - one of the last industrialized countries to do so.

In this paper, I want to examine some dimensions of the problem of occupational health and safety in Canada, and then discuss the characteristics of the new Canadian Centre and the activities it will undertake.

The Problem

Occupational health and safety in Canada is not just a health problem or a safety problem, but also an economic one. It costs Canadians enormously in injury, disease and death and as well, in dollars and productivity. Payments made to workers as a result of injuries, illnesses and fatalities on the job amounted to approximately 1 billion dollars in 1977. This statistic, as well as those on fatalities, loss of work days and compensation claims, comes from the reports of the Workmen's Compensation Boards in Canada. This covers only about 80% of the paid work force. In addition, little of the impact of industrial disease is reflected in these figures.

Another way of looking at the direct costs is through the number of hospital patient days paid for by compensation authorities. In 1975 this amounted to half a million patient days in Canadian hospitals which is equivalent to using 1,400 hospital beds every day for work-related injury and disease.

Each year from 1967 to 1976 an average of 1200 Canadians died as a direct result of their work. Again it must be stressed that deaths resulting from occupational disease are virtually not captured in these statistics. The fatality figure for 1975 was 1,168 while for 1974 it was 1,413. Preliminary figures for 1976 indicate that the total will again be well over 1,000. The most hazardous industries are mining, forestry and fishing. Goods producing industries as a whole account for one-third of all workers employed and covered by Workmen's Compensation Boards but accounted for two-thirds of all fatalities.

Another aspect of the magnitude of the problem in Canada can be seen by the fact that more working days are lost as a result of disabling employment injuries and fatalities than are lost through industrial disputes, though we are often more aware of the latter. Estimated days lost in 1977 due to employment injuries and illnesses is 12,000,000 and is equivalent to the year round employment of 56,000 workers. This compares to 3,300,000 days lost through industrial disputes.

Each year the injuries and illnesses resulting from work causes increase, not only in number or frequency but also in severity. This is to some extent reflected in the growing amount of the compensation claims, averaged out for every employee in Canada. In 1967 this average claim was $29.00, in 1976 it had risen to $83.00. From another perspective this increase in total costs of compensation was 19% from 1975 to 1976 alone while the payroll increase for the same period was 15%.

Indeed increase seems to be the only constant. There were nearly 11 compensable injuries/illnesses for every 100 workers in 1976 for a total of 1,044,008, excluding fatalities. From 1967 to 1976 there has been a steady increase in the number of disabling injuries as compared to non-disabling injuries. In 1967 disabling injuries accounted for 34.4% of all injuries and non-disabling injuries for 65.6%. By 1976 this had changed to 42.5% for disabling injuries and 57.5% for non-disabling.

An indication of the lack of emphasis that Canada has placed on occupational health and safety is the dearth of professionals in this field in our country. This also means that in some ways we are ill-equipped to correct or improve the situation. While the figures are not exact it is estimated that Canada has only 3 trained occupational health and safety professionals for every 100,000 workers, while in the United States this figure is approximately 30 per 100,000. We need to train our own and place emphasis on unique Canadian problems. Recognition of this has resulted in the establishment of occupational health and safety programs in our educational institutions during the past few years.

One of the greatest problems in the field is that we know so little. More than 85% of job related deaths are attributed to accidents but new studies indicate that occupation-linked disease is rising as a cause of death. National disease registries or data banks do not exist for most diseases or for injuries directly or potentially work-related or work-induced. The number of victims of long-term industrial disease is unknown. The true extent of the contribution of work and the work environment to mental illness, psychological (and social) problems, fetal abnormalities, chronic degenerative diseases, minor induries, and the exacerbation of underlying conditions is not documented in Canada.

Yet each year at least 200 new health hazards or problems arise and the majority of these are associated with the workplace. In addition more than 3,000 new chemicals and materials are put into use each year with very little pretesting done regarding their effect on human health.

The Complexities

For Canada, occupational health and safety is also a political problem as well as an economic and social problem. The size, diversity and multi-jurisdictional character of Canada make the occupational health and safety scene a very complex one. There are 13 separate, principal jurisdictions - 10 provincial, 2 territorial and the federal jurisdiction. More than 14 federal departments and agencies administer legislation or have a regulatory or facilitative role. Even so, industries under federal jurisdiction along with crown corporations and the federal public service account for only 10% of the paid work force.

Existing legislation is massive and complex, and grows each year. There are some 220 provincial and federal laws and 400 sets of regulations. Since 1972 when the Province of Saskatchewan implemented the first comprehensive provincial legislation in Canada and consolidated occupational health and safety activities in the Department of Labour, several provinces have reviewed their legislation and activities in occupational health and safety and have moved or are moving towards

consolidation: included are Alberta, Manitoba, Ontario and Newfoundland. Nevertheless, there are some 70 provincial departments and agencies involved in some aspect of occupational health and safety.

There are 20 national, non-governmental and 50 provincial, non-governmental organizations with a direct role in occupational health and safety. Three hundred others across Canada have an indirect involvement. There has been growing recognition of this complexity and the desperate need for cooperation and collaboration, yet change has been slow in evolving.

The Canadian Centre

A federal government initiative in response to this recognized need is the establishment of a Canadian Centre for Occupational Health and Safety. The proposal received support during consultations throughout Canada with labour, management, scientific, academic, professional and medical groups as well as with governments. The Act creating the Canadian Centre was passed on April 17, 1978.

Until now, Canada has been the only major, industrialized nation that does not have a central body to provide a common focus and initiative for occupational health and safety efforts. But Canada is also a unique country and any such Centre must have certain attributes to enable it to best serve the people of Canada.

Characteristics

There are five major characteristics which are basic to the Centre's Canadian personality. Firstly, it is not a regulatory body and has no regulatory powers. It will cooperate with all existing jurisdictions and will act as a catalyst to spur on action where it is needed. It will not compete or conflict with any jurisdiction. There are sufficient regulatory bodies now and regulation alone has not been a sufficient solution.

Another prime characteristics of the Centre is the openness with which it will work. The Centre will make the information it collects and the scientific data it acquires available to all. It will disseminate information widely but will also provide information on request. If the Centre is to influence change in occupational health and safety in Canada it must equip individual Canadians with authoritative information so that they may act as "inspectors" and "catalysts" in their work places.

The Centre is also required by legislation to receive briefs and representations from all interested groups or individuals and must account for its response to such briefs each year. In addition the results of any research the Centre commissions or initiates must be made public within 90 days of receipt of the study report. Only in such a spirit of openness can cooperation and shared confidence thrive.

The Centre must not only have information but it must have the independence to speak out strongly on vital, and sometimes controversial, issues. It will not be part of any government department or agency but an independent, self-governing and autonomous body. Its real accountability will be through the work it accomplishes for Canadians. The reports it publishes must not be government reports, management reports or labour reports - but independent ones.

In order to ensure that it truly represents the interests of Canadians and is non-biased, the Centre must have a multi-partite governing body. The Council of Governors will include representatives from each province, from the two territories, from management and workers organizations and from the federal government. Even in decision-making, such as that concerned with risk assessment, the judgement process is best when it rests with a group of individuals of varied backgrounds and interests. In occupational health and safety, with so much vital work to be done, only a multipartite council, representative of all Canadian interests should have the right to decide on priorities for action.

The excellency of the work it carries out will be the only mechanism by which the Centre can gain credibility and that credibility is the only authority the Centre has. It must attract the best Canadian talent, not only to its small permanent staff, but to its Council and to the projects that it undertakes.

Activities

The specific projects the Centre undertakes and the priority order of these projects must be decided by the Council when it is in place. There are, however, four major groupings of activities which will certainly be crucial to the Centre's functioning.

Research will be a major activity thrust for the Centre. Canada is behind in research on work hazards, the development of warning systems and of remedial measures. There is no lack of vital research work that the Centre must stimulate and support. Wherever possible this will be done in cooperation with existing facilities. In order to avoid duplication, and

foster better utilization of our limited resources, the Centre must undertake a review process of research projects related to occupational health and safety.

The reports that the Centre issues must be factual and without the value judgements of particular interests or of any jurisdiction. They will put forward the best existing knowledge on any hazard or problem area. Facts must be known first then disseminated and value judgements must come afterwards. In many instances the Centre's work can lead to the publication of criteria documents aimed at stimulating standard setting action by the appropriate jurisdictions.

Another of the Centre's main activities will be the collection, evaluation and dissemination of information on occupational health and safety. It will establish an information system, computer based and linked with knowledge sources within Canada and world-wide. A library and learning resource centre will enable it to respond to queries and make information on exposure levels, for example, available without constraint to working men and women.

Much information to form a data base to enable connections to be made between exposure to hazards and subsequent disease or death does not exist in Canada now. Therefore, another activity area will be the initiation of studies to enable record linkages to be made.

In order to meet its basic objective of promoting the fundamental right of Canadians to a healthy, safe work environment, the Centre will concern itself with the stimulation of human resource development. In cooperation with existing educational institutions, the Centre will undertake specific activities to increase Canadian expertise in occupational health and safety. Because of the tendency on the part of each discipline to view and interpret the whole field in its own terms, the Centre will promote a multidisciplinary educational approach, thus encouraging a common ground of understanding.

Structure

To carry out these activities and to ensure its independence and non-biased nature, the Centre has a governing council of 39 members as follows: 10 representatives nominated by the lieutenant governors in council of each of the provinces; two chosen by the commissioners of each of the territories; four from federal departments and agencies; 11 selected in consultation with workers' organizations and 11 selected in the same manner representing management organizations. The Chairman, as well as all other members of this Council, will be appointed by the Governor in Council.

A minister of the government will be the voice of the Centre in Parliament. The responsibility of the minister under the legislation is limited to receiving the Centre's annual report, financial statement and audit report and to ensuring that these documents are tabled in Parliament as well as distributed to the Provinces and Territories. The many provisions of the Act, including the fact that the Centre itself is empowered to make by-laws for the conduct and management of its affairs, ensure that the Centre will operate at arm's length from the Government and clearly establish its independence.

The Chairman is a part-time position while the President is the full-time executive officer. He chairs the Executive Board which is chosen from and by the Council. The Board has an equal number of members representing workers' organizations and management organizations and they comprise fifty percent of its membership.

Because of the determination to build an agency which will complement existing Canadian resources, and because of the widespread support for the Centre, the permanent staff will be small, numbering about 100. The staff will include specialists in health, engineering and other pure and applied sciences as well as safety and information specialists. They will not be part of the Public Service. Experts will be drawn in to participate in particular projects without becoming permanent staff members. The organization of the staff will be along a matrix concept, to promote flexibility, participation and the sharing of expertise.

At the outset the Centre will be financed by monies granted by Parliament. With the approval of the Centre's Council, financial support can be given by other participating groups. The annual budget is projected at about $10 million, a figure that is only 1% of the $1 billion now being expended each year in compensation payments as a result of injury and illness on the job.

The planning for the Canadian Centre for Occupational Health and Safety has followed the thinking of Dr. John F. Finklea, the former Director of the National Institute of Occupational Safety and Health in Washington, in that it has recognized "..... at the outset that labour, industry, the universities, health professionals, and government officials must all be aware of the complex issues involved and should, to the maximum extent possible, build a national effort on a consensus that recognizes our needs for healthy minds, healthy bodies, and a healthy economy." In a keynote address to the

Canadian Public Health Association (Canadian Journal of Public Health, Supplement two to Vol. 67, Sept.-Oct., 1976) Dr. Finklea exhorted Canadians to " .... make sure you keep public health and preventive medicine in your occupational safety and health efforts." This plea has not been lost on the architects of the Canadian Centre for Occupational Health and Safety.

AIR POLLUTION FROM INDUSTRIAL AND MUNICIPAL OPERATIONS

by: C.B. Martin
Ontario Ministry of the Environment

The topic given me today is "Pollution from Industrial and Municipal Operations". This is extremely broad and impossible to cover in all its aspects - liquid wastes, air pollution, process control, land usage, etc. - in the time available. I will deal primarily with air pollution and touch only briefly on some of the other aspects. Focus in this seminar is health in relation to pollution and this will be emphasized. However, it is important to note that while health is usually discussed in terms of direct health effects, other effects are considered in setting air quality objectives (on vegetation, soil, water eco systems, etc.) and these often have indirect health effects due to concentration buildups in the food chain, e.g. P.C.B.'s and arsenic.

Before dealing with the mechanisms of setting ambient air quality objectives and air emission control regulations, it would be pertinent to outline peripheral and supportive mechanisms.

First, there is the similarities and differences between inplant and explant situations (i.e. between occupational and environmental health). Both situations deal with the effects of pollutants on human health. However, inplant air pollution affects people of working ages for a limited exposure time (nominally 40/hrs/week), whereas explant pollution affects all ages 24/hrs/day, 7 days/week. As a consequence ambient air quality objectives are invariably lower than occupational health levels, and emissions must be controlled at source, i.e. personal protective equipment is not an option where outside air quality requirements are being considered.

Second, there are similarities and differences between liquid industrial pollution and air pollution. Both discharge contaminants to a fluid medium i.e. water, (including ground water) and atmospheric air. In both cases the contaminant discharge concentration is decreased by the flow of the mainbody of the fluid into which the discharge is made, and modifies the ambient condition of the main fluid downstream

of the point of discharge. There the similarity ends because the natural system for renewing the main fluid is quite different for water and air, and because one fluid (water) is confined to definitive channels, while the other fluid (air) is not. This has some fundamental consequences on the legislation and source control mechanisms associated with industrial pollution control of water and air. For instance, you can prohibit swimming in a given stream, but you cannot prohibit breathing in a given area. In the human health context you can designate stream usage, but not air usage. I understand that a future seminar is being planned to deal in some detail with liquid industrial waste and this paper will be dealing primarily with air pollution, albeit there are some crossover areas which will be mentioned.

Third, in the matter of industrial/commercial/municipal air pollution control in Ontario, it is important to recognize that there is a network of comprehensive interlocking legislative/administrative mechanisms in place to carry out and support this function. Under the Environmental Protection Act there are published air quality criteria, source emission standards (impingement standards), certificates of approval for new sources and changes to existing sources, Directors Orders to modify existing situations, and special regulations. In the field of good land use planning, there are the requirements under the Environmental Assessment Act for the proposed major new projects. Ontario's legislation is based on effects and this fact is reflected quantitatively in the air quality criteria and guidelines. The source emission standards and guidelines are set so that, in general, if everyone abides by them, the air quality criteria will be satisfied. However, if, because of special circumstances the general source emission standards are ineffective in achieving the desired ambient air quality, there is provision in the Environmental Protection Act to make special regulations which may be specific as to time or place, or both; e.g. there is a Sulphur-in-Fuels regulation for Metropolitan Toronto to help control SO_2 levels in the city; there is an Air Pollution Index in a number of cities to control ambient air conditions under adverse weather; in Hamilton the "Director's Order" mechanism was used to control particulate emissions whereby major sources were required to control their emissions by some 90%.

On the subject of failure of emission controls, under RRO.15,

Section 9, source owners/operators are required to report equipment failure immediately and the Provincial Officer may allow continuance, partial continuance, or shut down, depending on the cirumstances.

Since ambient air quality management is the objective of the legislation and enforcement system, Ontario maintains ambient monitoring stations in over 100 areas of the province, employing more than 1400 instruments. In addition, this network is supplemented by a number of air quality studies, such as the Sudbury Environmental Study and the Nanticoke Environmental Study.

Given a comprehensive and legal enforcement mechanism to control air pollution from industrial/commercial/municipal operations, the central issue is "control to what degree - and on what basis?". This involves the determination of ambient air quality criteria and the corresponding emission standards.

In Ontario, air quality objectives are based on the examination of all known effects on each contaminant and are in terms of time-concentration values which are below a known significant adverse effect. The expression "significant effect" used here is meant to exclude such a minor effect as the reversible short term dilation of the pupil of an eye. The term significant effects is categorized into four major groups; effects on man, animals (including fish) vegetation (including aquatic plants) and property. In order to do this, expertise must be available for each of the various disciplines involved. Thus there is a requirement for expert medical advice for human response; veterinary, agricultural and limnology experts for animals and fish; phytotoxicology for vegetation, and physicists, scientists and engineers for the evaluation of effects on materials. In each of the field of expertise a conscious attempt must be made to obtain data from wherever it is available in the world. This evidence must be documented and be made readily available to any interested enquirer. On the basis of evidence a value is proposed for the ambient air quality objective. Normally, this is stated as a 24 hr. average concentration, but it may, and often is, supported by concentrations at other time values, e.g. average annual concentration and average hourly concentrations. Table I gives a summary of this type of activity. Table II is an example of a contaminant data summary sheet showing the evaluation of effects in terms of a limiting

time-concentration in each category of effects. Each data summary sheet is accompanied by the pertinent documentation supporting the time-concentration values determined. This documentation is not shown in the example because it would be too voluminous and is irrelevant for this paper. The specific documentation and evaluation of this data may be, and in fact should be, open to question, particularly by the scientific community. That is fair and proper. Nevertheless this process of determining ambient air objectives does provide a reasonable and open scientific rationale for the ambient air quality objectives.

Unfortunately there is, at present, a severe practical difficulty with this process. It arises primarily in the field of health effects, where the contaminant under consideration has known or suspected carcinogenic, mutagenic, or teratogenic properties, and it is not scientifically possible with present data to establish a "no effects" or "absolutely safe" level This leads into the controversial and vital subject of "acceptable risk". In controlling pollution sources it is totally impractical for the medical or scientific community to say simply, that for such compounds, "source emissions should be kept to a minimum". The best achievable level of control has no clear cut definition; any control device can be improved upon, another stage can always be added, ad infinitum. Hence, in any specific case it is impossible to define this minimum "to which the source must be kept". Other speakers today have touched on aspects of this problem of "acceptable risk". I understand that the Environmental Protection Agency in the U.S.A. have made a start on the subject and are advocating three levels of risk categories:

level (1) is one cancer death/100,000 population

level (2) is one cancer death/1,000,000 "

level (3) is one cancer death/10,000,000 "

There is no easy solution but it is vital that the medical and scientific community address the problem seriously and vigorously. In the meantime we must proceed using some form of guideline, subject to revision.

In respect to the control of man-made emissions, given that agreed-upon ambient air quality objectives have been established, it is necessary to derive standards so designed that through their use the air quality objectives will be realized. In this endeavour it is important to note that ambient air quality is the end result of two independent factors; namely, source emissions and air transport. Air transport in this sense involves the assimilative capacity of the air, which, in turn, is influenced by meteorology, aerodynamic interference, topography and land-use.

The Ontario emission standards are stated in terms of time-concentration at the point of impingement (on a receptor) of the effluent stream, rather than as a conventional source emission number. The point of the emission is related to the point of impingement by the codified use of plume rise and diffusion equations. Thus this type of emission standard takes some reasonable cognizance of emission conditions, micrometeorology, land usage and topography.

In setting an emission standard, conscious effort is made to relate the allowable rate of emission to the ambient air objectives. However, since there are many factors which affect ambient air quality as a result of man-made emissions, there is a significant element of judgement involved in this process. One of the elements is consideration of the effects in terms of time. In this respect all Ontario point of impingement standards are stated in terms of 1/2 hr. average concentrations. The following is a list of the main factors currently evaluated in determining any 1/2 hr. impingement concentration standard which is aimed at achieving the desired ambient air objectives. (A summary of these is shown in Table III).

1. Sampling time differential. The ambient air objective is first translated from its normal terms of 24 hr. average concentration to a 1/2 hr. average concentration using as a basis the time concentration curves produced by investigators such as Nonnebel, Wippermann and Meade. Generally speaking, the ratio of 1/2 hr. to 24 hr. value is taken as 3 to 1.

2. Background contaminant concentration is considered. This is usually done by considering whether the contaminant is a commonly emitted one or whether it is an unusual substance. This includes factors of transport since a number of sources may contribute to air quality at a receptor. Also considered is whether the contaminant is present in the natural environment in significant concentrations.

3. Practical considerations of emission control. In setting an impingement standard to meet an ambient air objective, consideration of cost if not normally used as a factor because the objective of the exercise is to achieve the air quality objective. However, in special circumstances, source control technology can be used to help to set the standard. For example, in the case of a substance for which the determinate factor in arriving at the air objective is odour, and where the odour threshold is reported to be a wide range (e.g. hydrogen sulphide) then considerations of cost of control may help determine which end of the threshold odour range is chosen.

4. Other factors which should be considered when appropriate in judging the relationship between ambient air and the emission standard. These include such things as synergistic reactions, air reactions and any special health considerations which may be involved in time dosage.

With the contaminants, carbon monoxide and arsine as examples, Table IV shows a summary of the use of this evaluation system for determining impingement standards related to ambient air objectives. At the present time there are ambient air objectives and impingement standards for over one hundred air contaminants. Ontario has been using the above system of air quality objectives and standards for about ten years and air quality measurements have shown that the system works well. To illustrate the point, Graph A shows the trend over the years of SO_2 concentrations for various communities in Ontario.

One final comment on the subject of industrial pollution control may be appropriate. The required level of control can usually be met, at some cost, by the use of properly engineered add-on type of control devices (e.g. scrubbers, incinerators, cyclones, baghouses, etc.) with appropriate exhaust stacks. The type size and efficiency of the control device and the design of the chimney (with or without a control device), are all economic engineering decisions which are options for the industry, provided only that the operation of the resulting complex meets the standards, regulations and guidelines. Very often, however, requirements can be met more economically, and in some cases provide a good return on investment, through consideration of process change or modification. This is particularly true with today's high cost of energy.

In summary pollution from industrial and municipal operations should be approached primarily in the light of achieving and maintaining good ambient air quality, which is reflected quantitatively in the ambient air quality criteria. The medical and scientific community most vigorously pursue a resolution to the problem of acceptable risk in order to define adequately the desirable air quality objectives.

TABLE II

Selection of Limiting Ambient Air Criterion

Air Contaminant	-	Ethylene
Effect on human health	-	No known Health Effects (Acts as inert gas)
Effect on animals	-	Same as above for land animals. (Due to ethylene volatility and insolubility in water it poses little threat to aquatic life or vegetation)
Effect on property and materials	-	No corrosive or soiling properties Odour threshold level = 400 ppm (480,000 ug/m^3)
Effect on vegetation	-	Can cause leaf, flower and fruit drop. Recommended ambient air objective = 40. ug/m^3 (24 hr. ave.)

(Documentation for each of the above effects would normally be attached)

TABLE III

Factors Involved in the Determination of a 1/2 hr. ave. Standard

1. Average sampling time differential
2. Background concentration of the contaminant
3. Practical consideration of emission control
4. A variety of unique factors such as synergistic effects, air reactions, and special health considerations

Table IV

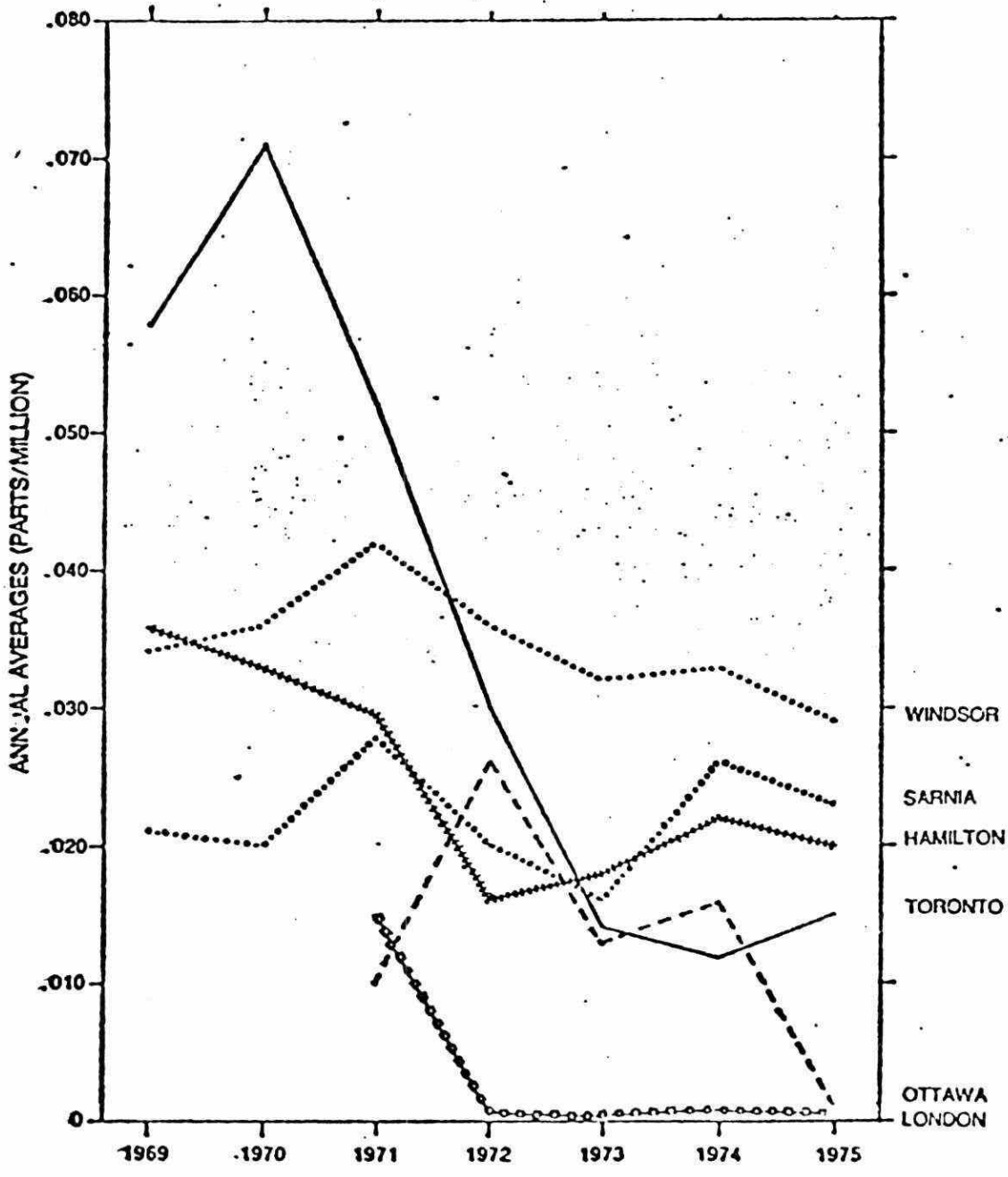
Derivation of 1/2 Hour Ave. Standard from the 24 Hour Ave. Ambient Air Objective

	Carbon Monoxide	Arsine
Limiting Ambient Air Objective	15,700 ug/m^3 (8 hr.)	5 ug/m^3 (24 hr.)
1/2 hr. Ave. (Based on Sampling Time Differential)	33,600 ug/m^3	15 ug/m^3
Background Concentration	Large Contribution from Mobile Sources	Not Significant
Practical Considerations of Control	Combustion Source Emissions Evaluated to Determine Lower Practical Limit of Proposed Standard	Not Applicable
Specific Concerns Either Long or Short Term	Nil	Ceiling Limit for Short Term Exposure set on the Basis of Health Considerations
1/2 hr. Ave. Standard Proposed	6000. ug/m^3	10. ug/m^3

GRAPH A

SULPHUR DIOXIDE LEVELS, BY SELECTED CITY 1969-1975

(Ontario Statistics 1976 Vol. I Social Series)



By: T.A. Constantine, P.Eng.
M. M. Dillon Limited
London, Ontario

ENVIRONMENTAL HEALTH AS A FACTOR IN DESIGN

1. INTRODUCTION

FIRST OF ALL, I WOULD LIKE TO SAY THAT THIS PAPER WILL NOT DISCUSS THE HEALTH PROBLEMS RELATING TO IONIZING RADIATION OR NOISE, EACH OF WHICH COULD BE HANDLED AS A PAPER ON THEIR OWN. NEITHER WILL THE PAPER DISCUSS THE TOPIC OF WORKER COMFORT WHICH IS ALSO QUITE SEPARATE FROM THE MAIN THRUST OF THIS PAPER, WHICH DEALS WITH EXPOSURE TO HAZARDOUS CHEMICALS.

THE TITLE OF THIS PAPER WAS ORIGINALLY GIVEN TO ME AS "DESIGN AS A FACTOR IN ENVIRONMENTAL HEALTH". AS A RESPONSIBLE CONSULTING ENGINEER, I FEEL MORE COMFORTABLE BY CHANGING THE TITLE OF THIS PAPER TO "ENVIRONMENTAL HEALTH AS A FACTOR IN DESIGN". IN YEARS GONE BY, WE HAVE SEEN MANY INSTANCES, BE THEY MANUFACTURING FACILITIES, POLLUTION CONTROL PLANTS, UTILITY INSTALLATIONS, MINES, OR STORAGE AND TRANSPORTATION FACILITIES, ETC. WHERE THERE HAVE BEEN IDENTIFIABLE DEFICIENCIES IN DESIGN WITH RESPECT TO ENVIRONMENTAL HEALTH. WE HAVE HEARD FROM EARLIER SPEAKERS ABOUT HOW THE MEDICAL AND INDUSTRIAL HYGIENE FIELDS HAVE PROGRESSED IN RECENT YEARS AND IN MOST CASES WHERE DESIGN DEFICIENCIES ARE STILL FOUND IN FACILITIES, THE CAUSE CAN USUALLY BE TRACED TO EITHER A LACK OF MEDICAL KNOWLEDGE OF THE PROBLEM DURING THE DESIGN OR IGNORANCE OF THE PROBLEM BY THE DESIGNERS.

TO KEEP PACE WITH THE INCREASED LEVEL OF KNOWLEDGE AS TO ENVIRONMENTAL HEALTH EFFECTS OF VARIOUS MATERIALS, SOPHISTICATED DESIGN CONSULTANTS TOGETHER WITH RESPONSIBLE OWNERS BOTH IN THE PRIVATE AND PUBLIC SECTORS ARE NOW PUTTING OUT DESIGNS WHICH INCORPORATE THE UTMOST IN PROTECTION FOR BOTH THE WORKERS AND THE SURROUNDING COMMUNITY.

THIS PAPER DISCUSSES HOW A DESIGN CONSULTANT APPROACHES A PROJECT INVOLVING ENVIRONMENTAL HEALTH CONSIDERATIONS. TYPICAL TYPES OF HAZARDS ARE DISCUSSED AND EXAMPLES FROM REAL DESIGN CONSIDERATIONS ARE GIVEN.

2. CONSULTING ENGINEER'S APPROACH TO ENVIRONMENTAL HEALTH ASPECTS

THE MOST IMPORTANT THING TO A CONSULTING ENGINEER UNDERTAKING A PROJECT WITH ENVIRONMENTAL HEALTH ASPECTS IS TO KNOW THE SUBSTANCES AND THE PROCESSES INVOLVED. THE PHYSICAL AND CHEMICAL PROPERTIES OF THE SUBSTANCES SUCH AS VAPOUR PRESSURE, BOILING POINT, FREEZING POINT, CORROSIVITY, FLAMMABILITY, DUSTING, EXPLOSIVITY, AS WELL AS THE TOXOLOGICAL PROPERTIES BOTH ACUTE AND CHRONIC MUST BE FULLY UNDERSTOOD. WHEREAS THE PHYSICAL AND CHEMICAL PROPERTIES ARE STRICTLY WITHIN THE REALM OF ENGINEERING, THE CONSULTANT MUST RELY ON THE MEDICAL DOCTORS AND ENVIRONMENTAL AND INDUSTRIAL HYGIENISTS TO PROVIDE DATA ON SUCH PROPERTIES AS TLV, ALLOWABLE SHORT TERM AND LONG TERM EXPOSURE DOSAGES. THE CONSULTANT MUST ALSO

UNDERSTAND THE MODE IN WHICH THE SUBSTANCE PRESENTS A HAZARD SUCH AS:

- BY INHALATION (E.G., CHLORINATED ORGANICS, MERCURY, DUSTS, AROMATIC HYDROCARBON AND TOXIC GASES SUCH AS PHOSGENE);
- BY SKIN OR EYE CONTACT (E.G., ACIDS, CAUSTICS);
- BY INGESTION (E.G., PESTICIDES, HERBICIDES, BIOCICLES).

MANY SUBSTANCES SUCH AS PCB'S CAN ACT IN SEVERAL DIFFERENT MODES TO ADVERSELY AFFECT HUMAN HEALTH.

MOST JURISDICTIONS HAVE REGULATIONS AND GUIDELINES REGARDING ALLOWABLE EXPOSURES AND REQUIRED PROTECTIVE MEASURES. IN ONTARIO, WE ARE FORTUNATE THAT BOTH THE MINISTRIES OF HEALTH AND LABOUR HAVE BEEN LEADERS IN DEVELOPING REGULATIONS AND GUIDELINES TO PROTECT WORKERS AND CITIZENS OF THIS PROVINCE. IN ADDITION, RESEARCH AND CO-ORDINATION WITH OTHER JURISDICTIONS ARE USED TO CONTINUALLY UPDATE CURRENT KNOWLEDGE ON TOXICOLOGY. ALLOWABLE LIMITS FOR HUMAN EXPOSURE ARE PERIODICALLY REVIEWED AND OFTEN REVISED UPWARDS OR DOWNWARDS TO REFLECT THE BEST AVAILABLE KNOWLEDGE.

ALWAYS, IT APPEARS THAT THERE ARE VERY GENEROUS "SAFETY FACTORS" APPLIED TO THE MAXIMUM ALLOWABLE VALUES OF THE CRITICAL PARAMETERS. WHEREAS ENGINEERS FEEL A GENEROUS SAFETY FACTOR IS FIVE OR SIX FOR AN ENGINEERING PARAMETER SUCH AS ALLOWABLE TENSILE STRENGTH FOR STEEL, THE PEOPLE SETTING HEALTH STANDARDS OFTEN WORK WITH SAFETY FACTORS OF 100 OR 1,000. THIS CONSERVATIVE APPROACH, OF COURSE, IS JUSTIFIED BY:

- ALLOWANCE FOR UNKNOWNS;
- VARIATIONS BETWEEN RECEPTORS;
- SYNERGISTIC EFFECTS WITH OTHER AGENTS;
- MINIMIZATION OF RISKS.

IN ADDITION TO THE REGULATIONS AND GUIDELINES AVAILABLE FROM HEALTH AND LABOUR, THERE ARE SEVERAL GENERALLY ACCEPTED PRACTICAL HANDBOOKS ON VARIOUS ASPECTS OF ENVIRONMENTAL HEALTH. AN EXAMPLE OF ONE SUCH AIDE IS THE PUBLICATION ENTITLED "INDUSTRIAL VENTILATION" PRINTED BY THE AMERICAN CONGRESS OF GOVERNMENTAL INDUSTRIAL HYGENISTS.

MOST IMPORTANTLY, HOWEVER, THE CONSULTANT MUST RECOGNIZE WHAT HAZARDS THE SUBSTANCES MANUFACTURED, STORED, OR HANDLED IN HIS PROJECT PRESENT. HE CAN FIND OUT TO WHAT LEVEL HIS DESIGN MUST PREVENT EXPOSURE TO WORKERS AND THE SURROUNDING COMMUNITY AND HE MUST DESIGN THE FACILITIES TO PROVIDE A WORKING AND COMMUNITY ENVIRONMENT WHICH WILL NOT PRESENT A HAZARD TO HEALTH.

ALLOWANCE MUST ALSO BE MADE IN THE DESIGN FOR "FAIL-SAFE" SYSTEMS AND FOOLPROOFNESS TO MINIMIZE THE RISKS DUE TO HUMAN FAILURES.

IN SUMMARY, PROBABLY THE TWO MOST DIFFICULT TASKS THE DESIGN CONSULTANT HAS IN A PROJECT INVOLVING ENVIRONMENTAL HEALTH ASPECTS ARE FIRSTLY, TO CORRECTLY IDENTIFY THE PROBLEMS AND TO ESTABLISH THE RIGHT DEGREE OF PROTECTION AND TO CONVINCE UNENLIGHTENED OWNERS OF THE NECESSITY OF FACILITIES SOLELY FOR WORKER AND COMMUNITY HEALTH PROTECTION.

3. CONTROL OF EMISSIONS AND RELEASES

3.1 GENERAL

RELEASES AND EMISSIONS OF HAZARDOUS SUBSTANCES MAY TAKE MANY FORMS AND ENDANGER, IN VARYING DEGREES, THE HEALTH OF THE SURROUNDING COMMUNITY AND/OR THE WORKERS. GENERALLY, RELEASES AND EMISSIONS MUST BE EVALUATED UNDER THREE DIFFERENT CONDITIONS:

- NORMAL OPERATION;
- UPSET OPERATION (E.G., START-UPS, SHUT-DOWNS, OPERATING PROBLEMS, ETC.);
- DISASTER CONDITIONS (E.G., FIRE, EARTHQUAKE, EXPLOSIONS, VEHICULAR ACCIDENTS, MAJOR EQUIPMENT FAILURES, ETC.).

RELEASES AND EMISSIONS CAN BE BROADLY CATEGORIZED AS EITHER:

- RELEASE OF A HAZARDOUS LIQUID OR SOLID TO WATER AND/OR SOIL;
- RELEASE OF A HAZARDOUS GAS, VAPOUR, DUST OR AEROSOL TO THE ATMOSPHERE. (THIS TYPE OF A RELEASE CAN ALSO BE A SECONDARY EFFECT OF A SPILL OF LIQUID OR SOLID.)

IN THE FOLLOWING, A BRIEF DISCUSSION ON EACH CASE IS GIVEN. GENERAL REFERENCE WILL BE MADE TO A PROJECT OUR FIRM IS PRESENTLY WORKING ON - A STORAGE AND HANDLING FACILITY FOR POLYCHLORINATED BIPHENYLS.

3.2 Release of Hazardous Liquid or Solid to Water and/or Soil

THIS KIND OF AN EVENT IS USUALLY CALLED A "SPILL". NATURALLY ALL DESIGNERS SELECT EQUIPMENT AND MATERIALS SO AS TO AVOID THE POSSIBILITY OF SPILLS. SPILLS, HOWEVER, CAN OCCUR DUE TO EQUIPMENT AND MATERIAL FAILURES BUT ARE MORE PREVALENT WHERE A TRANSFER OPERATION FROM A CONTAINER TO ANOTHER VESSEL IS INVOLVED. ALTHOUGH NOT USUALLY OF IMMEDIATE CONSEQUENCE TO HEALTH, SPILLS OF HAZARDOUS SUBSTANCES CAN ENDANGER POTABLE WATER SUPPLIES AND CAN CAUSE CONTAMINATION OF SOIL AND OTHER MATERIALS IN CONTACT WITH THE SPILLED MATERIAL.

THERE ARE ALSO ENVIRONMENTAL HEALTH CONSIDERATIONS INVOLVED WITH THE CLEAN-UP OF THE SPILL. ALTHOUGH CLEAN-UP AND DECONTAMINATION OF THE AREAS AFTER A SPILL USUALLY ONLY TAKES A SHORT TIME, EXPOSURE OF THE CLEAN-UP CREW TO THE SPILLED MATERIAL IS OFTEN A SERIOUS CONSEQUENCE. MOST OFTEN, CLEAN-UP OPERATIONS CANNOT BE MECHANIZED AND SPECIAL PROVISION MUST BE MADE WITH RESPECT TO PROTECTIVE EQUIPMENG (E.G., RESPIRATORS, EYE PROTECTION, ETC.) AND CLOTHING AS WELL AS CLEAN-UP UTENSILS AND TOOLS. CLEAN-UP PROCEDURES MUST BE CAREFULLY PLANNED AND CONTINGENCY PLANS SHOULD BE AVAILABLE TO STAFF IN THE EVENT THEY ARE REQUIRED ON SHORT NOTICE. IN SOME INSTANCES WHERE QUICK EFFICIENT RESPONSE TO A SPILL IS MANDATORY, CLEAN-UP CREW MEMBERS SHOULD BE DESIGNATED AND TRAINED IN THE PROCEDURES USING DRY RUNS SIMULATING A SPILL.

LASTLY, THERE HAVE TO BE PROVISIONS FOR DISPOSAL, DESTRUCTION OR PERPETUAL STORAGE OF THE SPILLED SUBSTANCE RECOVERED PLUS ANY SOIL AND OTHER MATERIALS THAT MAY BE CONTAMINATED.

SOME EXAMPLES OF THE MEASURES THAT WILL BE DESIGNED INTO PCB FACILITIES TO HANDLE SPILLS ARE DISCUSSED IN THE FOLLOWING. REFER TO FIGURE NO. 1.

THE TRUCK MANOEVERING AND UNLOADING AREA WILL BE A LARGE REINFORCED CONCRETE SLAB,CURBED AND GRADED TO A SERIES OF CATCHBASINS LEADING TO A BLIND SUMP TANK. A HEAVY GAUGE SYNTHETIC FILM WILL BE PLACED UNDER THE SLAB. THE SUMP WILL BE LARGE ENOUGH TO CONTAIN ALL OF THE STORM WATER THAT FALLS ON THE CURBED AREA AND ALSO LARGE ENOUGH TO HOLD ONE LARGE TANK TRUCK VOLUME. THEREFORE, ANY SPILLED MATERIAL FROM TRUCKS CAN BE CONTAINED AND CLEANED UP WITH SOLVENTS. STORM WATER WILL ONLY BE RELEASED FROM THE SUMP TO THE LOCAL DRAINAGE COURSE BY PUMPING AFTER AN ANALYSIS HAS SHOWN IT TO BE BELOW THE ALLOWABLE LIMIT SET FOR DISCHARGE TO SURFACE WATER.

IN THE WAREHOUSE AREA, WHERE DRUMS OF PCB'S ARE STORED, A CURBED, SEALED CONCRETE AREA IS PROVIDED TO CONTAIN SPILLS. IN THE BULK STORAGE AREA, STORAGE TANKS ARE BUILT IN SEALED CONCRETE DYKED AREAS WHERE SPILLS WOULD BE CONTAINED.

RECOVERED SPILLED PCB'S PLUS SOLVENTS AND OTHER CONTAMINATED MATERIALS WILL BE PUT INTO CONTAINERS FOR STORAGE PRIOR TO ULTIMATE DISPOSAL. A FULL RANGE OF PROTECTIVE CLOTHING AND DEVICES WILL BE PROVIDED FOR CLEAN-UP CREWS. CONTAMINATED PROTECTIVE CLOTHING WILL BE PLACED IN SEALED CONTAINERS AND STORED FOR ULTIMATE DISPOSAL.

3.3 Emissions to the Atmosphere

Knowledgeable consulting engineers design facilities for manufacturing and handling hazardous substances so that the substances are contained in the equipment, vessels, tanks and piping. However, during normal operation of facilities, there are very often sources of emission that sometimes require special treatment. Examples are:

- Air/vapour mixtures displaced from tank filling operations;
- Non-condensable gases in process vent or purge streams;
- Vacuum pump discharges;
- Vapours and dusts from loading/unloading operations.

Each individual circumstance must be evaluated to see if secondary collection and treatment systems are required. Whether such systems are required or not involves examining the concentrations resulting from the emission(s) in the atmosphere at both the work place (work-day exposure) and in the community (annual exposure). Examples of secondary collection systems to control emissions would be:

- dust collection and filtration system;
- scrubbing, adsorption and/or incineration of vent streams;
- controlled loading/unloading systems employing vacuum.

DESIGNERS MUST ALSO PROVIDE FOR CONTROL OF EMISSIONS DURING "UPSET" CONDITIONS. OF COURSE, THESE OCCURRENCES ARE ON AN INFREQUENT BASIS AND THE EXPECTED FREQUENCY AND DURATION MUST BE TAKEN INTO ACCOUNT WHEN INVESTIGATING THE NEED FOR SPECIAL TREATMENT. EXAMPLES OF "UPSET" CONDITIONS ARE:

- PROCESS MALFUNCTIONS (E.G., CAUSING INCREASED VENTING RATES OR SAFETY VALVE OPENING);
- START-UP OR SHUT-DOWN PROCEDURES (E.G., CAUSING INCREASED VENTING RATES, OR PURGING OF EQUIPMENT);
- MINOR EQUIPMENT FAILURES (E.G., SEALS OR PACKING LEAKS).

SCRUBBING, INCINERATION (OR FLARING) OR ADSORBTION CAN BE USED TO CONTROL EMISSIONS FROM "UPSET" CONDITIONS. ANOTHER APPROACH WHICH HAS BEEN USED IS TO INSTALL CERTAIN EQUIPMENT OR VESSELS IN WELL VENTILATED OUTDOOR LOCATIONS OR TO EXTEND VENT STACKS AND TAKE ADVANTAGE OF NATURAL DISPERSION, PROVIDED EMISSION RATE DOES NOT EXCEED REGULATORY REQUIREMENTS. AS WITH NORMAL EMISSIONS, THE CONCENTRATION OF A HAZARDOUS SUBSTANCE IN THE WORK-PLACE AND COMMUNITY ATMOSPHERE RESULTING FROM EMISSIONS FROM UPSET CONDITIONS MUST BE FULLY EXAMINED AS TO POTENTIAL EFFECTS ON HEALTH.

RECENTLY, WE HAVE EXPERIENCED THROUGH THE LENS OF A TV CAMERA THE RESULTS OF NEAR DISASTERS SUCH AS THE HARRISBURG AFFAIR. WE HAVE ALSO SEEN THE EFFECTS OF RAILROAD TANKCAR ACCIDENTS WHICH RELEASED LARGE AMOUNTS OF HAZARDOUS CHEMICALS TO THE

ATMOSPHERE. INSTANCES SUCH AS THESE HAVE EMPHASIZED THAT WHEREVER POSSIBLE, THE DESIGNER OF A FACILITY WHERE A HAZARDOUS MATERIAL IS MADE OR HANDLED MUST MINIMIZE THE RISK OF A RELEASE IN THE EVENT OF A DISASTER SUCH AS A FIRE, EARTHQUAKE, EXPLOSION, MAJOR EQUIPMENT FAILURE (E.G., LARGE PROCESS VESSEL, TANK, ETC.) OR A MAJOR TRANSPORTATION CONTAINER ACCIDENT.

IN THE CASE OF POTENTIAL EARTHQUAKES, THE DESIGNER CAN EMPLOY SPECIAL STRUCTURAL CONSIDERATIONS THAT MAY BE WARRANTED IN THE ZONE IN WHICH HE IS WORKING.

PREVENTION IS THE BEST CURE FOR OTHER TYPES OF MAJOR DISASTERS. IF WARRANTED, EXTRA DESIGN FEATURES CAN BE EMPLOYED SUCH AS:

- EXPLOSION ANTICIPATORS AND RAPID EMERGENCY VENTING TO PREVENT SERIOUS EXPLOSIONS;
- DOUBLE WALL CONSTRUCTION FOR TANK TRUCKS OR TANK CARS CARRYING HAZARDOUS MATERIALS;
- CONTAINMENT BUILDINGS FOR CRITICAL VESSELS AND TANKS;
- FIRST CLASS FIRE FIGHTING SYSTEMS WHICH ARE COMPATIBLE WITH THE SUBSTANCE BEING HANDLED.

IN THE CASE OF THE PCB STORAGE AND HANDLING FACILITIES, THE FOLLOWING DESIGN FEATURES WERE INCORPORATED TO MINIMIZE NORMAL EMISSIONS:

- "TIGHT" PIPING AND STORAGE SYSTEMS;
- PNEUMATIC TRANSFER FROM TANK TRUCKS TO STORAGE TANKS TO MINIMIZATION OF PUMPING;
- PACKING-LESS VALVES;
- ADSORPTION OF STORAGE TANK VENTS.

IN THIS FACILITY AT WHICH NO PROCESS-TYPE DISPOSAL FACILITIES ARE PLANNED AT THIS TIME, THERE IS NO NEED TO CONSIDER EMISSIONS FROM "UPSET" CONDITIONS.

FROM EXPERIENCE IN STORING PCB SUBSTANCES, IT IS KNOWN THAT THE ATMOSPHERE IN THE BUILDING WILL CONTAIN SOME PCB. THIS RESULTS FROM CO-DISTILLATION WITH WATER SUCH AS CONDENSATION INTO THE ATMOSPHERE FROM SOURCES SUCH AS MINUTE LEAKS IN DRUM BUNGS AND STORED EQUIPMENT, AND MAINTENANCE ON VALVES AND EQUIPMENT, ETC. A VENTILATION SYSTEM HAS BEEN DESIGNED SO AS TO MAINTAIN THE WORK AREA AT A CONCENTRATION WELL BELOW THE ALLOWABLE. THE VENTILATION EXHAUST WILL BE PASSED THROUGH AN ADSORBER PRIOR TO DISCHARGE TO THE ATMOSPHERE. THE VENTILATION AIR FLOW AND CONCENTRATION WERE USED IN THE MODELLING OF A "NORMAL EMISSION RATE" FOR THE FACILITY TO PREDICT POTENTIAL IMPACT ON THE SURROUDINGS.

THE WORKPLACE WILL BE MONITORED FOR PCB WITH AN ANALYZER. SPOT CHECKS USING GRAB SAMPLES WILL ALSO HAVE TO BE DONE.

TO GUARD AGAINST DISASTER CONDITIONS, MATERIALS WILL BE SELECTED AND BULK TANKS DESIGNED SO AS TO AVOID THE POSSIBILITY OF FAILURE.

TRAFFIC PATTERNS AND CONTAINER HANDLING WILL BE SUCH THAT THE RISK OF ACCIDENT IS MINIMAL. THE CONTAINER WITHIN A CONTAINER STORAGE CONCEPT WILL BE USED FOR SOME CONTAMINATED EQUIPMENT WHICH REQUIRES STORAGE (E.G., CAPACITORS).

4. EMPLOYEE WELFARE FACILITIES

EMPLOYEE WELFARE FACILITIES SHOULD BE TAILORED TO SUIT EACH INDIVIDUAL CASE WHERE HAZARDOUS SUBSTANCES ARE HANDLED. GENERALLY INCLUDED ARE FIRST AID FACILITIES AND WASHROOM, LUNCH ROOM AND LAVATORY AND SHOWER FACILITIES. IN THE CASE OF THE PCB STORAGE AND HANDLING FACILITY, THE LAYOUT IS SHOWN IN FIGURE NO. 2.

NOTE THAT SEPARATE LOCKER ROOMS ARE PROVIDED FOR STREET CLOTHES AND WORK CLOTHES AND THAT THE SHOWER ROOM IS BETWEEN THE TWO. THE WORKERS MUST SHOWER BEFORE CHANGING BACK TO STREET CLOTHES AT THE END OF THE DAY. ALSO, BEFORE GOING TO THE LUNCH ROOM, THE WORKERS MUST PASS THROUGH THE WASH-UP AREA. A SEPARATE TOILET FACILITY IS ALSO PROVIDED FOR THE WORK AREA.

5. CONCLUSION

WITH PROPER ATTENTION GIVEN AT THE DESIGN STAGE, MANUFACTURING AND/OR HANDLING FACILITIES FOR HAZARDOUS CHEMICALS CAN BE BUILT THAT WILL MINIMIZE THE RISKS TO THE HEALTH OF BOTH THE WORKERS AND THE SURROUNDING COMMUNITY.

THE FUTURE WILL SEE A CONTINUING EFFORT TO OPTIMIZE DESIGN FOR NEW FACILITIES AND PROVIDE REMEDIAL MEASURES FOR OLDER PLANTS.

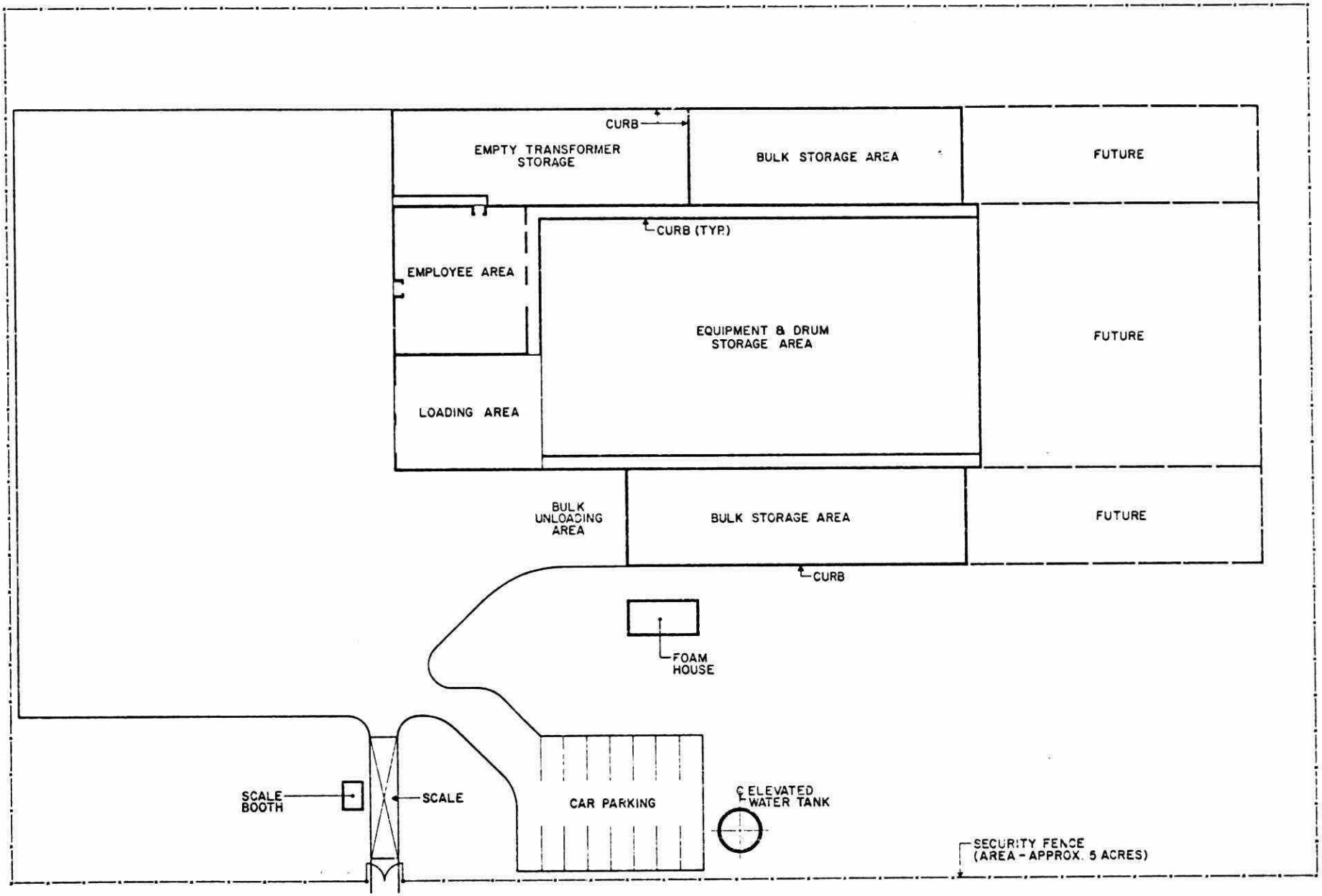

CURB
EMPTY TRANSFORMER STORAGE
BULK STORAGE AREA
FUTURE
CURB (TYP.)
EMPLOYEE AREA
EQUIPMENT & DRUM STORAGE AREA
FUTURE
LOADING AREA
BULK UNLOADING AREA
BULK STORAGE AREA
FUTURE
CURB
FOAM HOUSE
SCALE BOOTH
SCALE
CAR PARKING
ELEVATED WATER TANK
SECURITY FENCE (AREA - APPROX. 5 ACRES)

FIGURE No. 1

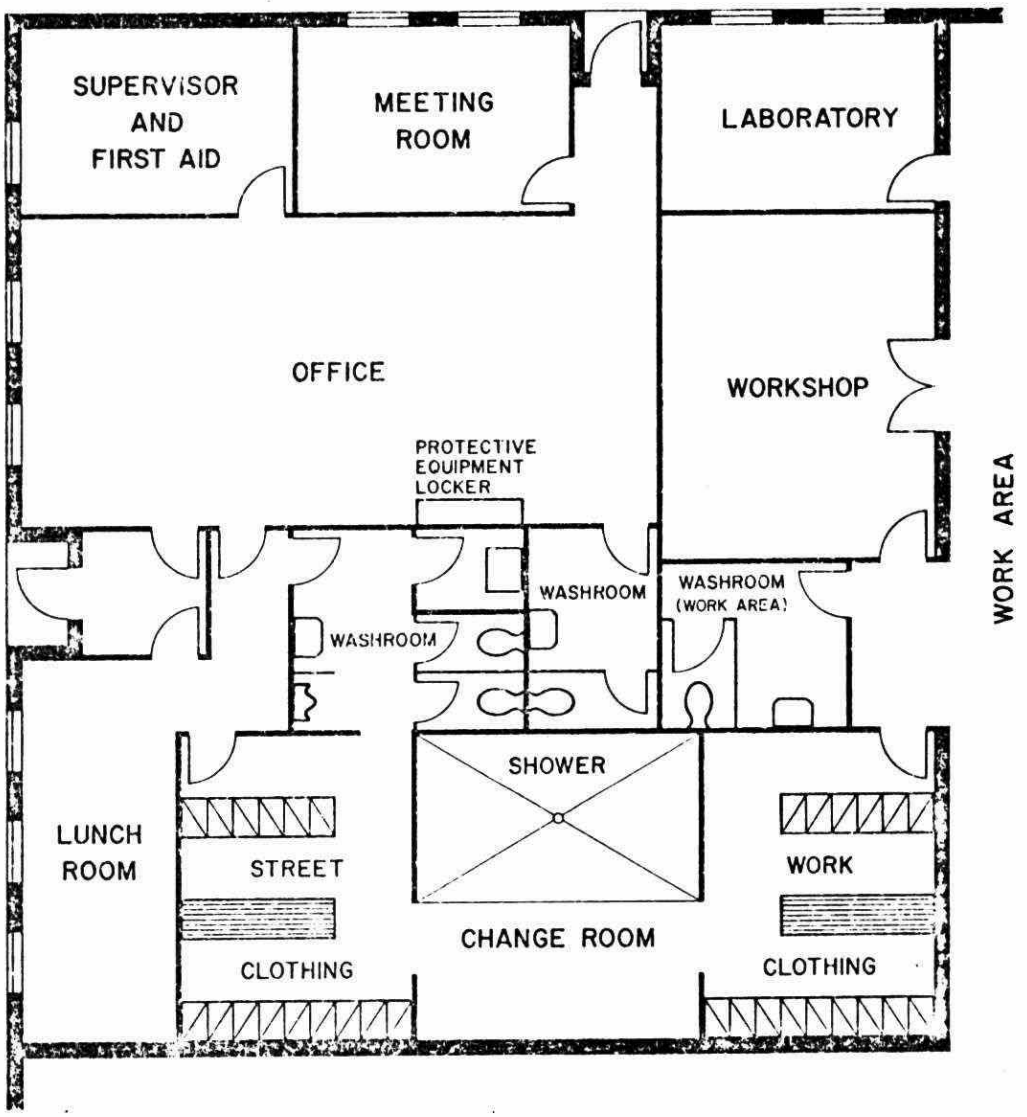

SUPERVISOR AND FIRST AID
MEETING ROOM
LABORATORY
OFFICE
WORKSHOP
PROTECTIVE EQUIPMENT LOCKER
WASHROOM
WASHROOM (WORK AREA)
WASHROOM
WORK AREA
SHOWER
LUNCH ROOM
STREET
WORK
CHANGE ROOM
CLOTHING
CLOTHING

FIGURE No. 2

Development of Canada's Drinking Water Guidelines

by: V. Douglas, Health & Welfare, Canada

Introduction

Today we find a growing need for water in nearly all sectors of the national economy, for energy production for irrigation, for manufacturing, for mining and of course household uses. In 1972, over 31,000 million gallons per day of fresh water, equivalent to 1400 gallons per day per person was withdrawn from Canada's fresh water supply.[1]

What I would like to do today is to outline to you the threats posed to our water supplies, what has been done about it in the past and what we are attempting to do about it today.

We all know that Canada is a fortunate "water rich" country. Abundant water supplies have helped develop our national economy. The same water source however has also become the repository of many of our wastes.

Today over 60,000 natural or synthetic chemicals are used in daily life, and over 1000 new substances are marketed each year. Many of these chemicals find their way into our soil, waterways, food and air. In addition, many of these chemicals further degrade or transform as a result of natural environmental processes, or are changed by or within living organisms which have absorbed or ingested them. Many of these chemicals form a potential threat to man, and many of them may have reached our drinking water supplies.

Environmentalists have been threatening us with Malthusian doom, where population growth would be exponential and food production would increase arithmetically. Pessimism was further expounded in the popular book 'Limits to Growth'[2] (Quote) "If the present growth trends in world population, industrialization, pollution, food production and resource depletion continue unchanged, the limits to growth on this planet will be reached

sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity".

Indeed this picture appears gloomy. The basic principle of 'Limits to Growth' is that pollution is killing people, and the rate of kill increases with industrialization. These rapid changes appear to inspire an anti-technology feeling and a desire to return to a simpler nongrowing world.

I don't however subscribe to these ideas. Rates of change are accelerating because of scientific research and the consequent rapid technological improvements. But know-how accumulates, man learns to do new things faster, and old can give way to new ideas. The poorer countries would welcome our pollution if it would mean industrialization and economic improvement. Ask a poor man: "Would you prefer a loaf of bread or a cleaner river?" Then ask a rich man.

However in the world of tomorrow we will have to manage our social institutions and our natural resources carefully. In the case of our natural waters this means a total environmental plan, each action complementing the rest.

History and Jurisdiction

The need for management of our national resources has long been recognized. The British North America Act of 1867 gave the Parliament of Canada responsibility for fisheries and navigation. Thus over the years the federal government has come to enact laws concerning the pollution of waters inhabited by fish, navigable rivers, harbours and federal lands. This Act does not deal directly with water resources. Under the act, the ownership of all natural resources is vested in the provinces, and

ultimately, the provinces have primary authority over municipal water supplies. However, under the Food and Drug Act, the Minister of National Health and Welfare has the authority to proscribe, by regulations, standards for food and consequently, for water. It appears, therefore, that federal and provincial jurisdictions over drinking water overlap. In practice, the regulations developed by both levels of government tend to complement each other.[3]

The history of drinking water standards goes back to 1923 when the Federal Government passed an "order-in-council" regulating bacteriological quality of drinking water on vessels traversing inland waters. Later this was extended to all common carriers, and coastal shipping.

In the "forties" and "fifties" the U.S. Public Health Service Standards were generally accepted and used by the Department of National Health and Welfare. In the sixties it appeared necessary to develop Drinking Water Standards for Canadian waters which often differred from those of the U.S. Thus a Drinking Water Committee was set up under the auspices of the Canadian Public Health Association and a Subcommittee formed by the Department of Health and Welfare. In 1968, the Canadian Drinking Water Standards and Objectives were drawn up and published by the department of National Health and Welfare.[4]

In 1974, the Department of Health and Welfare established a Federal-Provincial Working Group for revising the drinking water standards. In addition to ten Provincial representatives, both the Department of Health and Welfare and Department of the Environment sent delegates to the "working group" meetings. At these, 'mini-conferences' local, provincial and national problems were debated and discussed. We feel that the new "1978 Guidelines for Canadian Drinking Water Quality" is a document truly representative of the interests and opinions of the provincial representatives.

I would like to stress that the limits described in the Federal Guidelines are not legally enforceable standards unless promulgated as such by the appropriate provincial or federal agency.

Development of new Guidelines

In developing these new guidelines the 1968 Standards were critically re-examined in the light of new information. The recommended levels accordingly were either modified, changed, retained or discarded. Furthermore new parameters were considered and reviewed and some new levels were set. All of the parameters will be briefly outlined in the 1978 Guidelines[5], while fuller description will be available in a separate publication "Supporting Documentation - Guidelines for Canadian Drinking Water Quality - 1978".[6]

Why did we revise the standards? Firstly, because of the tremendous public concern over pollution. As you know, the sale of bottled drinking water as well as the sale of water purifiers and stills is on the upswing because of concern over so called 'poisons' in our drinking water. Secondly, because (as previously mentioned) a multitude of chemicals is used in our everyday life, thus we had to determine whether or not our drinking waters contribute to our total load of exogenous harmful chemicals. Thirdly, because the total withdrawal of water is ever increasing and consequently the "water returns" to our waterways cause waters which are less palatable, warmer, higher in inorganic salts, total organic and bacterial counts. These, of course, tend to lower our surface water quality and ultimately our potable water palatabilty and quality. Fourthly, because many parameters have not been evaluated before. Of particular concern today are the possible adverse health effects of trihalomethanes which are formed during the Chlorination disinfection process. Other chlorinated organics and heavy metals were also of concern. And lastly because of

improvement in our analytical methodologies, hitherto unsuspected substances have been found in our drinking water. These are then the reasons which provided the impetus to revise the drinking water guidelines.

The next question that comes to mind is: How did we arrive at the recommended "limits"? This, I have been told, is of most interest to you. This brings to my mind an anecdote I heard from a friend. As he was passing through a small Ontario town, he saw signs of some amazing marksmanship - on signs, fenceposts, trees. There were bulletholes right through dead centre. He soon found the expert shot - an eleven year old boy. "My boy, this is amazing. How did you shoot all those bullseyes?" he asked the lad. "Easy" he said. "I shoot first and draw the circles after." Well despite our amazing marksmanship, that is not what we have done to come up with our recommended levels. True, when we had the latitude or flexibility we tried to take a realistic approach. After all, you cannot set a limit for a substance below its detection limit. But despite some very very limited data we have been asked to set certain limits. This is the way we approached it.

Our main concern was, and is, to maintain and safeguard human health. We felt that we were not setting guidelines to protect the most sensitive aquatic organisms. That is Environment Canada's job. Human health,however, implies not onl the absence of disease and infirmity but includes aesthetic satisfaction as well. Thus we divided our parameters to two groups: those we justify solely on aesthetic considerations, and those that may cause adverse health effects. In addition, a few non-specific parameters were found to have neither aesthetic nor health implications, but which did influence the acceptability of drinking water.

In establishing acceptable levels, two types of limits have been established: a "Maximum Acceptable Concentration" and an "Objective Concentration".

Maximum Acceptable — Drinking water that contains substances in concentration greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable.

Objective — This level is interpreted as the ultimate quality goal for both health and aesthetic purposes.

The maximum level should not be exceeded for above these limits waters may have the capability of producing deleterious health effects or will not be aesthetically pleasing. When the maximum acceptable concentration for a substance is exceeded, the waters should be immediately re-sampled, and if the limit is continuously exceeded, corrective action must be taken, especially if it is a health related parameter. The objective level is a long-term goal, the attainment of which should provide an improvement in water quality and which would have the additional effect of discouraging pollution. Waters which have reached the 'objective level' will be of best possible quality from health and aesthetics point of view.

These limits have been established based on the evaluation of scientific criteria. Criteria may be defined as "scientific requirements on which a decision or judgement may be based concerning the suitability of water quality for the preservation of the aquatic environment or to support other designated uses".[7]

In other words, we attempted to derive or recommend levels from a sound scientific basis. We assessed man's total daily intake of each parameter, from all ambient sources: from food, air, water and by contact. In addition, we tried to anticipate special situations such as smoking

or occupational exposure. Thus, we reasoned, if we could calculate man's intake of contaminants from tap water as well as from all other sources, if we could estimate his daily fluid intake and if we knew what levels are toxic or hazardous, then we can tell if man is at risk when he is exposed to this substance. Let me show the problems we have encountered with each.

1. Daily Fluid Intake

In calculating man's intake of contaminants from drinking water and water-based foods, we had to find out just how much water man drinks. The U.S. EPA has assumed a daily intake of 2 litres, the WHO International Drinking Standard assumed 2.5 litres. Yet in a Canadian national survey,[8] carried out under the guidance of the Department of Health and Welfare, it was established that the average daily intake from tap-water based fluid (tea, coffee, soups, popsicles, home-made beer and wine) is about 1.4 litres. The rationales for the Drinking water guidelines were based on a daily fluid intake of 2 litres, since this survey was carried out after the criteria documents were written. This, however, would tend to introduce an additional safety factor into the standards.

2. Total Daily Intake

The estimation of man's total daily intake involved literature searches into the levels of each chemical in average foods, or, if available, in typical Canadian diets; we often estimated intake consulting Canada's nutritional guidelines. The levels of heavy metals, such as mercury, were of special importance, since they often bioconcentrate in

the food chain. Take mercury, for example, since we had more information on this parameter than on many others. Mercury bioconcentrates rapidly in aquatic systems. Thus people who eat fish caught in these waters will be ingesting more mercury than others. The Working Group decided to protect the average Canadian and take 'ambient' exposure rather than maximal exposure. Therefore, in order to assess the level of mercury in foods, a study was conducted comparing the mercury in the representative diets of East Coast Canadians versus West Coast Canadians. Other surveys of mercury levels in fish, meat, food products and other diets were also consulted, and an estimate of daily mercury intake from food was established using this data. Some data on mercury levels in air were also found in the literature, although ambient air levels were very few. We did find information on mercury levels downwind from chlor-alkali plants and the full document contains a note on possible higher risk for those living in these areas. Potable water levels have been obtained from the provinces and, although scant, the data was sufficient to have an estimate of man's total daily intake.

3. Acceptable Daily Intake

Once we have established the average total daily intake of the so called "average" Canadian, we consulted our toxicologists to give us information on the "Acceptable Daily Intake". The ADI philosophy implies that lifetime exposure to the maximum acceptable level is theoretically without appreciable risk to man. The objective level of a toxic substance is set at the limit of detection, since in general the lower the intake of a toxic chemical, the lower is the risk.

4. Risk Evaluation

The evaluation of carcinogenic,mutagenic,and teratogenic substances is of special concern. The Federal/Provincial Working Group has agreed with departmental policy that the only acceptable level for a carcinogen, mutagen or teratogen is "not detectable". The ADI philosophy obviously cannot be applied here. In the case of man-made organics, the Working Group recommended that these should not be present in our water supplies. However, this is an academic statement, because some of these organics are there in our drinking water, and they are difficult, impossible or impractical to remove.

Regulatory decisions are further complicated by the fact that there is often little or no information available on the health effects of the "six hundred plus" organics identified in drinking water supplies. There is also a lack of agreement within the scientific community on such questions as characterization of carcinogens, significance of human exposure to very small quantities, extrapolation of experimental animal data to real-life human exposure. There are compounding problems of available treatment technology, lack of analytical capabilities and costs of treatment. Work is proceeding to provide solutions to these problems.

Let me illustrate the problem with carcinogenic substances. Trihalomethanes, chloroform, bromoform, dichlorobromomethane and dibromochloromethane are formed as a result of the disinfection process by chlorine.

A recent survey[10] of some 70 Canadian municipalities has shown that chloroform can reach 121 ug/litre. In the U.S. well over 300 ug/litre was found in the Mississippi River near New Orleans.[11] Epidemiological

studies of the lower Mississippi and Ohio rivers were unable to show a direct, clear cut relationship between chloroform in drinking water and cancer although there was a low level association between bladder cancer and chloroform. However, the U.S. National Cancer Institute has found a dose-response relationship indicating that chloroform may be an animal carcinogen. In addition, hepatotoxicity was known to occur in man when exposed to oral doses of chloroform between 1 and 25 mg/kg/day.

After considering several mathematical models proposed by various researchers our toxicologists decided that the most conservative model of Tardiff (Tardiff, 1977) would be a reasonable one to base risk assessment.

Slide 1 - illustrates the models considered by Tardiff.

It is felt that this extrapolation from animal studies to man is defensible because the target organs are known and metabolic pathways have been partly elucidated.[13]

Summary of the new Guidelines[5]

The guidelines have been divided into sections on the physical, microbiological, chemical and radiological characteristics of drinking water.

Slide 2 - illustrates the recommended limits for the physical characteristics

The physical characteristics are:

colour

odour

taste

temperature

turbidity

pH

Qualities of these parameters do overlap with the chemical parameters, (such as chloride levels and taste) thus the division is somewhat arbitrary.

However, some of these are the parameters that are first noticed by the consumer. The principal goal here is to provide an aesthetically pleasing drinking water. It is important to note however that such water may provide a false sense of security if health-related parameters are not also assessed.

(No Slide) Microbiological Parameters

The introduction of water disinfection and monitorying programmes has resulted in a dramatic decrease of waterborne diseases in Canada. The occasional outbreaks do point out the need for constant surveillance of our water supplies. In developing microbiological standards it has been recognized that contamination by sewage, or fecal pollution poses the greatest immediate danger to public health. The presence of such fecal pollution can indicate that dangerous pathogenic bacteria may be present. The document goes into some detail on coliform levels, sampling and recommends remedial actions as well.

Since the disinfection process is the step designed to destroy pathogenic organisms, it is discussed in conjunction with the microbiological parameters. The "Guidelines" recommend the maintenance of a small chlorine residual for two reasons: (1) To provide a quick and easy checkpoint for the proper functioning of the disinfection process; (2) To protect the distribution system against small bacterial invasions.

Chemical Characteristics

The aim of setting limits for these chemical parameters is to ensure that Canadians' health is safeguarded. However, another consideration is that: The maximum acceptable concentrations should be neither so low as to be impracticable nor so high as to encourage pollution. The chemical characteristics are divided into 4 parts:

(1) Fluoride

(2) Other parameters related to health

(3) Parameters related to aesthetic and other considerations

(4) Non-specific parameters

(1) Fluoride is a unique substance since its presence is carefully controlled to produce a desired beneficial effect.

(2) Health Related Parameters. The levels for these substances have been derived as outlined previously, that is, by assessing the possibility of adverse health effects after long exposures. The implications to human health in many cases are not well elucidated or understood. Some of the inorganic parameters, for example, may have an essential beneficial function, however, the main source of ingestion of these substances is food, not drinking water. If these substances were absent from drinking waters, the essential levels would be still attainable from foods, yet the toxic levels would be minimized. The objective levels for these substances are set at those detection limits routinely available in most laboratories.

The limits set for chemical substances are as follows:

Slide 3 - <u>Inorganic chemicals</u>:

Antimony
Arsenic
Barium
Boron
Cadmium
Chromium
Free Cyanide
Lead
Mercury
Nitrate
Nitrite
Selenium
Silver
Sulphate

Slide 4 - Organic chemicals:

NTA (Nitrilotriacetic acid)
Pesticides (Total)
Trihalomethanes

Others considered were: Asbestos (for which insufficient information was available to base a maximum acceptable concentration in drinking water), Sodium (which is not a toxic metal and up to 10 grams per day can be consumed as NaCl without adverse effects), and naturally-occurring organic chemicals (presumably these have always been present in potable waters).

Slide 5 - (3) Parameters related to aesthetic and other considerations. These parameters do not have direct health significance but could in excessive amounts, cause a deterioration of potable waters, such as lowering the palatability, staining fixtures or interfering with treatment processes.

These are:

Chloride
Copper
Iron
Manganese
Phenols
Sulphide
Zinc

(no slide)(4) Non-Specific Parameters

These are "group" parameters and include:

Hardness
TDS
TOC

Monitoring of these parameters may provide information of assistance to treatment plant personnel in establishing optimum water treatment processes.

Summary

The revision of the 1968 standards and the development of the 1978 Guidelines have been undertaken to promote and maintain the potability of water destined for domestic consumption.

Modern water treatment technology presumably can provide us with excellent drinking water; nevertheless, the quality of the raw water source from which the supply is obtained should be at a level consistent with the water treatment method available. Conflicts have arisen, for example, when waterwater disinfection, intended to alleviate microbiological problems, has caused the formation of new chlorinated organics. These eventually have contributed to the chemical pollution of the drinking water. The next speaker, I understand, will address this problem.

References

1. Anonymous, 1975. Canada Water Year Book 1975. 232pp. Information Canada, Ottawa.

2. Meadows, D. "Limits to Growth". 1972. Potomac Assoc. Publisher ISBN 0-87663-901-5

3. Somers, E. 1977. Criteria and Programs for Drinking Water Quality in Canada in: Drinking Water Quality in Canada. 224-234, Acad.Press. Inc.

4. Anonymous, 1969. Canadian Drinking Water Standards and Objectives 1968. Queen's Printer, Ottawa.

5. Anonymous, 1979. Guidelines for Canadian Drinking Water Quality, 1978. Prepared by Federal-Provincial Working Group on Drinking Water. National Health and Welfare publication.

6. Anonymous. "Supporting Documentation - Guidelines for Canadian Drinking Water Quality - 1978" to be published in 1979 by National Health and Welfare.

7. Working Group on Water Quality Criteria of the subcommittee on Water Quality. Interdepartmental Committee on Water, Department of the Environment. Guidelines for Water Quality Objectives and Standards. Technical Bulletin No. 67, Dept. of the Environment, 1970.

8. Private Communication. Dr. V.C. Armstrong. Health and Welfare Canada. A Survey of Canadian Drinking Water Consumption Patterns. Unpublished data.

9. Anonymous, 1978. Mercury-Drinking Water Criteria Review. Prepared by the Monitoring and Criteria Division, Health and Welfare Canada; to be included in "Supporting Documentation - Guidelines for Canadian Drinking Water Quality - 1978". Health and Welfare publication.

10. National Survey for Halomethanes (1977), 77-EHD-9, Health and Welfare Canada.

11. E.P.A. Office of ToxicSubstances. (1975). Preliminary Assessment of Suspected Carcinogens in Drinking Water Report to Congress. Dec. 1975. i.-52 and appendices.

12. Tardiff, R.G., (1977). J. AWWA 69:558

13. Anonymous, 1978. Trihalomethanes - Drinking Water Criteria Review. Prepared by the Monitoring and Criteria Division, Health and Welfare Canada; to be included in "Supporting Documentation--Guidelines for Canadian Drinking Water Quality-1978". Health and Welfare publication.

By: G. Victor Buxton, P.Eng.
Environment Canada

Wastewater Disinfection - A Multifaceted Problem

I would like to start off my talk this morning by relating to you a short scenario which depicts why the report from the federal Department of Environment entitled - Wastewater Disinfection in Canada was initiated, but more importantly it draws attention to the need for an integrated approach to multifaceted problems such as wastewater disinfection and underlines the need for clearly identifying the basis upon which recommendations, policies or regulations are made.

In early 1976, a Deputy Minister of a Provincial Environment Department from one of our prairie provinces contacted staff from one of our fisheries research facilities and asked for advice with respect to the need for disinfection at one of the larger municipalities within his province. It just so happened that researchers from the institute had just completed a comprehensive study of the River system to which the treated municipal sewage effluent (which was seasonally disinfected with chlorine) discharged.

Briefly, he reported back to this Deputy Minister that his studies had shown that:

(1) Chlorination had increased the toxicity of municipal wastes in acute lethal laboratory bioassays with fish and aquatic invertebrates.

(2) The discharge of chlorinated municipal wastewater killed caged fish downstream.

(3) The discharge of the chlorinated municipal wastes had been correlated with the decrease in numbers and also the disappearance of specified aquatic species.

He further pointed out that since this was only a two month study, the results did not assess the long-term effects of discharging chlorinated municipal wastes and such effects could include the production

of carcinogens deleterious to human health, and the accumulation of chlorinated by products in various aquatic species which could ultimately necessitate the closure of a current commercially exploited downstream fishery. He concluded by stating that from his fisheries management perspective the chlorination of municipal wastewater was a retrograde step in environmental management.

Unaware of this liaison, staff of a regional office of our Environmental Protection Service was also contacted by this same provincial department and asked for advice with respect to the need for a wastewater disinfection requirement for this same municipality. They replied suggesting that "to not disinfect" sewage effluent could introduce human health risks since the downstream water uses included water contact recreation, food processing and 10 miles downstream another municipalities water supply.

The provincial staff then packaged these two opposing recommendations and sent them to our Deputy Minister asking

(a) Does the federal government have a policy on wastewater disinfection and if so, what is it?

(b) Which service speaks for federal DOE on this issue?

My first task in relation to this disinfection issue was to prepare a reply to this letter pointing out the reasons for the different advice.

The second assigned task was to review the available and scientifically supportable data with respect to wastewater disinfection and to provide, if possible, a technical basis upon which a rational national policy on wastewater disinfection could be developed.

We recognized at the onset that we were dealing with a multi-faceted problem crossing many scientific disciplines and that we would require direct participation and/or input from each of the groups to

provide a comprehensive and unbiased basis from which various rating factors could be applied, trade-offs made and a recommended policy developed. Furthermore, it was recognized, also, at the onset that in order to ensure a "rational" recommendation on the public health side we would (1) have to examine the scientifically defensable data and/or the logic basis of existing criteria both domestic and foreign; (2) we would have to attempt to assess just how much of a health threat can logically be ascribed to bathing in "polluted" water and attempt to precisely quantify any "risk" reduction which could be attributed to wastewater (not drinking water) disinfection; (3) we would have to examine very closely the health impact of any chemical by-products created in an effort to reduce bacteria levels via chlorination.

On the ambient environment side of the issue, we would have to

(1) document very clearly the negative impact of chlorinated wastewater on aquatic ecosystems; (2) the relative environmental impact of alternative disinfectants and of course, (3) the relative direct costs of these alternatives.

The federal working group which was finally assembled involved many experts from NH&W including a representative from the Canada Centre for Disease Control. The disciplines represented on the working group were chemistry, microbiology, epidemiology etc. On the environment side the Representatives included bacteriologists, microbiologists, aquatic biologists, shellfish experts, chemists, engineers, all involved in some form or other with some facet of the disinfection problem.

The collective viewpoints (after much review for accuracy) which finally emerged is reflected in the report entitled "Wastewater Disinfection in Canada" copies of which are available. For the most part the appropriate responsibility centre assembled and assumed responsibility to verify the accuracy of the material presented, i.e. NHLO - public health related issues, DOE - environment impact etc.

I would like to briefly review the conclusion of this study.

Historical Aspects

1) A positive correlation exists between the chlorination of drinking water and the decline in typhoid fever deaths.

2) With respect to wastewater discharges to bathing waters, no scientifically acceptable epidemiological data which correlates wastewater chlorination practices with a decrease (or increase) in human health risk from bathing in such waters exists.

Existing Requirements - Domestic

Most provinces favour wastewater disinfection where there is a perceived potential health hazard. Saskatchewan, Manitoba, and Prince Edward Island assign their disinfection requirements on a case-by-case basis. Newfoundland, Nova Scotia, New Brunswick and British Columbia require year-round disinfection at all facilities, unless specifically exempted. Quebec, Yukon and the Northwest Territories do not generally require disinfection although Quebec insists upon the availability of equipment for use in emergencies. Alberta requires disinfection where a public health risk exists and Ontario requires seasonal disinfection only, unless there is a downstream use potential.

Existing Requirements - Foreign

U.S. disinfection requirements vary widely from state to state but in general reflect the same concern for public health exhibited in Canada.

Europe, in contrast, does not favour wastewater disinfection. Britain and Germany practice disinfection for emergency situations only; France, for discharge to shellfish areas; and Italy is presently developing guidelines for discharges to potable water supplies. In general, however, wastewater disinfection is <u>not</u> practiced in western European countries.

Public Health Aspects

1) Very low levels of water contamination with Salmonella typhi can cause typhoid in individuals drinking such water. However, the extensive pretreatment of water supplies substantially reduces the risk of such contact.

2) No significant correlation has yet been demonstrated between bacterial or viral counts and infections from the recreational use of waterbodies.

3) Criteria currently used in the design of chlorination facilities appear to be inadequate in terms of effecting required bacterial reduction in treated wastewater effluents.

4) Chlorination has the potential of reducing the natural bactericidal effect of receiving waters by removing predators and competitive microorganisms.

5) Chlorination tends to kill coliform bacteria more rapidly than the more resistant pathogens. Thus, the absence of faecal coliform in a chlorinated effluent should not be considered an indication that no pathogens of enteric origin are present. Although this could be the case without chlorination, it is less apt to be so when chlorination is utilized.

6) Massive doses of disinfectant are no substitute for adequate treatment of wastewater and only increase the potential threat to public health and the environment.

7) Greater emphasis should be placed on studying the total cycling of Salmonella in the environment rather than on inadequacy of existing detection methods. Major pathways of the recirculation process need be broken to effect a reduction in the present level of salmonella - contaminated foods.

8) Documented outbreaks of viral disease from water have largely been limited to the agent of infectious hepatitis.

9) Evidence that indicates resistance to chemotherapeutic agents can be transferred from one Gram-negative bacterium to another by R factors (episomes) exists.

10) The positive relationship between sewage pollution of shellfish growing waters and incidence of enteric diseases in humans is well established.

11) Epidemiological investigations of shellfish-transmitted disease outbreaks have never established a direct numerical correlation between the bacteriological quality of shellfish growing waters and the degree of hazard to health. Historical evidence appears to have established that enteric diseases are not usually transmitted by shellfish harvested from waters containing less than 70 total coliforms per 100 ml (MPN). A mean faecal coliform MPN value of 14 per 100 ml has been adopted as the standard for Canadian shellfish growing waters.

12) While chlorine disinfection of wastewaters prior to discharge is effective in removal of bacteria, current practices in chlorination are not effective in the inactivation of viruses. Chlorination as practiced today is, therefore, not a completely satisfactory means of public health protection.

13) Chlorinated wastewater effluents may contain stable chlorine-containing organic compounds which produce undesirable environmental effects and, because of their persistent nature, may be bioaccumulated and thus become potentially toxic to man via the food chain. Very limited information regarding uptake and bioaccumulation of compounds formed by the chlorination of wastewater and their subsequent entry into man's food chain is available.

14) The concentrations of the majority of the organohalogen compounds in receiving waters are extremely low. Considering the insignificant human intake of chlorinated wastewater, even during swimming, these compounds should not pose a hazard to human health through direct ingestion of raw water.

15) The toxicity of the trihalomethanes and chlorinated purines and pyrimidines has been studied. Although chloroform is carcinogenic in rodents at high doses, the risk to man from the low levels in chlorinated wastewaters appears to be minimal. Chlorinated purines and pyrimidines, at the low levels detected, pose little or no health hazard to man.

16) The assessment of the toxicity of stable compounds, formed in significant quantities during the chlorination of wastewater, is of importance to human health. Chronic toxicity studies in animals on daily ingestion of low levels of chlorine-containing organics have not been carried out for many of the organohalogen compounds detected in chlorinated wastewaters.

Impact of Chlorinated Wastewaters on Aquatic Ecosystems

1) Recommended concentrations of minimum residual chlorine levels for disinfection are between 0.5 mg/l and 1.0 mg/l. With respect to municipal wastewaters, residuals are often maintained much in excess of this range.

2) Residual levels in the range 0.5-1.0 mg/l are well below those known to demonstrate physiological effects on mammals.

3) The toxicities of free chlorine and chloramines are of the same order and a measure of total residual chlorine is generally adequate to define chlorine toxicity.

4) Whereas the concentration of residual chlorine to which an aquatic organism is exposed decreases as a function of distance from the effluent outfall, the residuals often remain in the toxic range for a considerable time (in excess of two days) and significant aging is required to dissipate chlorine induced toxicity.

5) Residual chlorine is actuely toxic to aquatic organisms at levels as low as 0.02 mg/l. Chronic toxicity is evidenced at levels in the order of 0.001 mg/l.

6) Residual chlorine is not as directly toxic to freshwater invertebrates as it is to fish. However, recommended (minimum) residual chlorine levels (0.5 - 1.0 mg/l) will eliminate fish food species and result in the long term reduction of fish populations.

7) The avoidance reactions of fish to chlorine, chloramines and chlorinated municipal wastes may affect the spawning and feeding movements of fish populations.

8) There is no evidence that chlorine itself can produce taints in the flesh of fish, but when it is present with phenols the resulting chlorinated phenols can produce taints at concentrations as low as 0.001 mg/l.

9) Research into the toxicity of residual chlorine to saltwater and estuarine species has not been extensive, but the toxic effect is believed to be comparable to that of freshwater species.

10) Very few studies concerning the effects of chlorine on molluscan shellfish exist. The limited studies indicate adverse effects on feeding behaviour and activity. At a residual chlorine level of 0.01 mg/l, inhibition of oyster pumping activity is apparent and the feeding activity of oysters receiving chlorinated and dechlorinated sea water is found to be significantly less than that of the oysters receiving the same water that has not been chlorinated.

11) High levels of chlorine residual will undoubtedly induce toxicity in shellfish and especially to their planktonic food organisms.

12) Water quality criteria for marine aquatic life, as proposed by the U.S. Environmental Protection Agency, state that maximum acceptable concentration of free residual chlorine in marine and estuarine waters to be 1/10 of the 96 hour LC_{50} value, determined using the receiving water in question and the most sensitive species of the locality as the test organism. Concentrations of free residual chlorine in marine and estuary waters in excess of 10 ppb are unacceptable. If the maximum acceptable limits recommended by the EPA for water quality criteria in shellfish growing areas were adopted in Canada, serious constraints would be placed on the use of chlorine for disinfection of domestic sewage.

13) Chlorine possesses the potential for combining with a wide variety of organic compounds to produce substances some of which are exceedingly toxic to aquatic organisms.

14) Chemical structure cannot, at present, be linked to potential toxicity. Therefore, the effects of chlorination must be determine empirically for most compounds. However, current work in the area of predictive toxicology could improve this situation.

Disinfection Alternatives

1) Current alternatives to chlorine for disinfection are as follows:
   - chlorination/dechlorination,
   - ozonation,
   - bromination (with bromine chloride),
   - chlorine dioxide,
   - lime addition to high pH,
   - ultraviolet radiation,
   - gamma irradiation (with Cobalt 60).

2) Chlorination-dechlorination appears to offer a technically and economically practicable alternative to conventional practice. Whereas dechlorination reduces or removes the chlorine-induced acute fish toxicity, little is yet known of the fate and health effects of any remaining chlorinated by-products.

3) Ozone appears also to offer a technically and economically viable (though more costly at present than chlorination by a factor of two) alternative. Whereas ozone can provide a degree of disinfection with no apparent acute fish toxicity, little is yet known of the public health effects of any reaction by-products. However, these are expected to be less severe than the chlorination by-products. Ozone, to be effective, may be applied only to good quality secondary or tertiary treated effluents.

4) Bromination, although in its embryonic stages of development, appears to offer potential as a technically and economically sound alternative.

5) Although chlorine dioxide is an effective disinfectant, a multiplicity of unknown and known hazards mitigate against its utilization at this time.

6) Ultraviolet radiation may prove to be an alternative where wastewater quality is high and the volume low.

7) Gamma irradiation appears impractical at this time.

8) Lab studies indicate that high pH lime treatment can give adequate disinfection with spin-off treatment benefits.

9) Information on operation, maintenance, reliability and safety of disinfection alternatives is deficient and more research both at the pilot scale and full scale operational level is required.

One might logically ask, what happens to our study now? Well, recognizing the intense interest of many Departments at all levels of government in this policy development exercise a presentation of this report was made to the Federal/Provincial Advisory Committee on Environmental and Occupational Health at their March 14, 1979 meeting in Edmonton and a request was made that the Committee consider striking a working group to develop this Federal policy recommendation.

The Committee accepted this request and the Ad Hoc policy development group is currently being formulated.

What we expect to emerge from this exercise is a federal recommendation on Wastewater Disinfection which will have received the widest possible review and which will offer an improved basis for decision making by all levels of government.

By: Ann H. Vajdic, Water Technology Section,
Ministry of the Environment,

Sewage effluent - is disinfection necessary?

Where the disinfection of sewage effluents is required, the use of chlorine is almost universal. In recent years, two important problems as a result of its use have been identified:

1. The chlorination of sewage results in the formation of compounds which, upon discharge to receiving waters, are toxic to various forms of aquatic life. The toxicity affects not only fish, their eggs and their hatchlings, but also microscopic organisms which serve as food sources for higher aquatic life (1, 2).
2. The chlorination of some organic constituents of sewage effluents may generate chlorinated organic substances which are refractory to biodegradation, and may be harmful to the health of humans consuming the receiving waters (3).

If chlorine is determined to be unacceptable as a sewage disinfectant, because of these problems, there are two possible courses of action. An alternative disinfectant could be developed for use in sewage; there are currently several under consideration (ozone, chlorine dioxide, ultra-violet), but their toxicity potential and possible harmful by-products have not been extensively studied, and they would almost certainly be more expensive. A second course of action might be to discontinue disinfection of sewage effluents, as is sometimes now allowed over the winter months in Ontario.

There is little data available on the effects of undisinfected sewage effluents on the aquatic environment (4), but there are certain facts which are known and can be considered in a rational assessment of that impact.

Human waterborne diseases are spread by ingestion of water contaminated by the disease organisms; these organisms are capable of multiplying in the intestinal tract of man (and sometimes animals and birds) and are therefore present in the feces of infected individuals.

These "enteric" diseases can be spread by other means, e.g. personal contact, but their method of spread by the water vehicle is depicted in Figure 1.

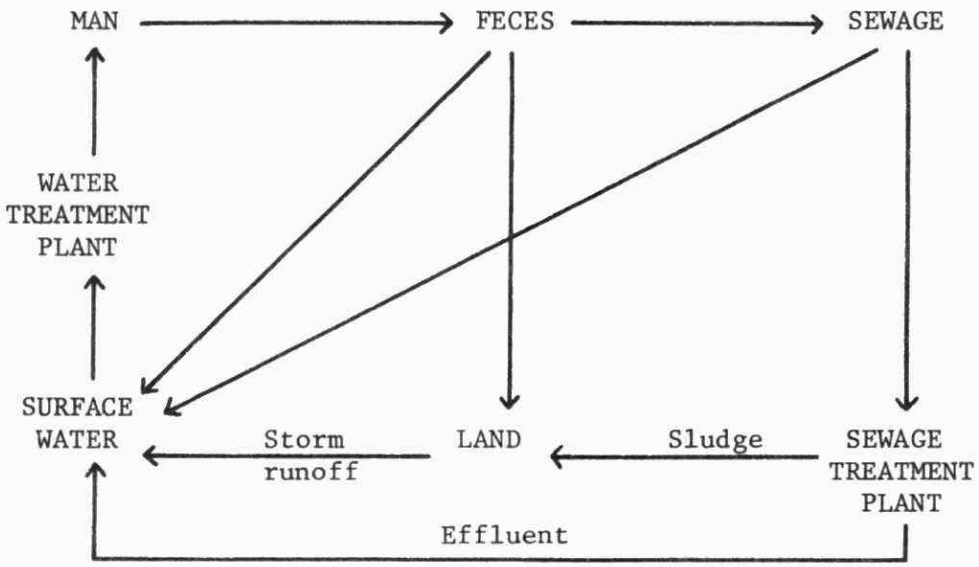


FIGURE 1. THE 'pollution cycle'

The toilet and other liquid wastes from a community are collected in the sewer system. Since a certain percentage of individuals in a community will be infected by enteric diseases at any one time, their wastes containing the disease organisms will also be present. At the sewage treatment plant the wastes are treated, but all the disease organisms may not be eliminated. The sludge is usually disposed of on agricultural land and the effluent is discharged to surface water. This surface water, containing the surviving pathogens, in a great many instances serves as the drinking water

source for another community. The transmission cycle would be completed on consumption of the untreated water. The sewage treatment plant, however, is not the only source from which fecal material containing enteric disease organisms can reach the surface water. Many animals and birds can carry and be infected by the same microorganisms that cause infection in man; their wastes can reach surface waters as a result of direct contamination, in run-off from feedlots and agricultural land and in discharges from storm sewers and packing plants. There is a great deal of evidence that these sources contribute considerably to the pollutional load of surface waters (5, 6, 7). The impact of sewage effluents must, therefore, be considered in relation to that of these other sources of pollution, which to a large extent are uncontrolled.

Enteric diseases can be caused by bacteria (typhoid, dysentry) viruses (hepatitis, poliomyelitis) or parasites (ascariasis, giardiasis); because these classes of microorganisms are physiologically different, the potential for each to contaminate surface water must be assessed separately. Various pathogenic bacteria, viruses and parasites are always present in raw sewage (8, 9), in numbers depending on the carrier and infection rate within the particular community, and can be readily isolated from the influent to most sewage treatment plants.

Bacterial pathogens, such as Salmonella types, are considerably reduced during secondary sewage treatment; their numbers are further reduced upon chlorination of the effluent, but they may not be eliminated entirely using current practice (10). The surviving bacteria can persist in surface water for several weeks, and have been found associated with sediments (11). Animals and birds can be infected with many of the same species of Salmonellae that infect man (although Salmonella typhi is apparently only found in man); these, and other potential pathogens such

as Klebsiella pneumoniae and Pseudomonas aeruginosa are also discharged in pulp and paper mill waters, packing plant discharges and storm and agricultural run-off (12, 13, 14). Sewage chlorination, therefore, reduces the number of pathogenic bacteria discharged from sewage plants, but there is a significant potential for contamination of surface waters with such bacteria from other sources. Despite current requirements for sewage disinfection, Salmonellae and other bacterial pathogens can be isolated with relative ease in many surface waters (15, 16).

The efficiency of the elimination of viruses by sewage treatment procedures varies widely, Table 1; activated sludge treatment is usually acknowledged to be the most effective, with removal efficiences varying from about 50-90+% (17). Since levels of viruses in incoming sewage have been estimated to be 600-1000 TCID50 per 100 ml (18), on average, even the highest removal rate would still leave 60-100 TCID50 per 100 ml entering the disinfection stage. These remaining viruses, because they are highly resistant to the action of combined chlorine, particularly in the presence of turbidity, would remain relatively unaffected by disinfection (19). It has been observed that 8 mg of chlorine per litre of sewage effluent resulted in no decrease in virus numbers (20). Therefore, sewage disinfection as currently practised is virtually ineffective in eliminating viruses from sewage effluent. Many of the viruses initially present in the sewage, become concentrated in the sludge. After digestion, it is felt (21), that sludge disposal on agricultural land under current regulations, poses a minimal hazard in terms of viral pollution of surface waters. Some bovine reoviruses can infect man, but the majority of enteric-type viruses affecting animals and birds are not directly transmissable. The potential for the direct contamination of surface water with human enteroviruses is therefore small, except for that due to combined sewer bypass. The

majority of human enteric viruses in surface waters enter via sewage effluents and would do so even if the effluents were chlorinated. Therefore, despite current chlorination requirements, human enteric viruses can be readily isolated from surface waters (22).

Parasites are the third group of microorganisms which must be considered. Some of these require intermediate hosts, but the ones which must be considered in waterborne spread are these which can be transmitted directly between individuals, such as Enterobius vermicularis, Trichuris and Ascaris; the life cycle of which is shown in Figure 2 (23). Also, parasites which can infect both animals and man, are important; an example is Giardia lamblia (Figure 3), which has been responsible for several outbreaks of waterborne intestinal disease in the U.S. (24).

Parasites characteristically produce, at some stage of their life cycle, a highly resistant body (cyst or ovum) which can survive adverse environmental conditions and serve to transmit the infection. These resistant forms are shed in the feces of infected individuals, and therefore are present in raw sewage. Good secondary treatment removes the cysts and ova from the sewage prior to disinfection, but should any reach the disinfection stage, they would remain unaffected by the levels of chlorine normally used (25). Regulations for sludge disposal minimize the hazards to surface waters from this source. There may be some potential for direct contamination for several parasites, but for Giardia lamblia this appears to be the primary way by which contamination of water supplies occurs. In one of the outbreaks (26), the cysts reached the water source by direct contamination from beavers.

The following facts are therefore apparent:-

1. Pathogenic microorganisms can be isolated from surface waters, despite current disinfection practices.
2. Viruses are not reduced in numbers during disinfection of sewage effluents; bacteria can be considerably reduced in numbers during chlorination, but there are significant inputs of such bacteria from other sources; parasites are usually effectively removed in sewage treatment processes prior to disinfection, but inputs from other sources can cause contamination of surface waters, and have been responsible for waterborne disease.
3. Even if chlorine disinfection of sewage were improved in efficiency, or alternative disinfectants were used, the other sources of contamination (storm flows, agricultural run-off, packing plant wastes, etc.) would still exist. The problems of the aquatic toxicity of the effluents, and the generation of reaction products which could be harmful to human health would still remain.

Sewage effluents are disinfected historically to protect the health of those utilizing the receiving water as a drinking water source or for recreational purposes; the effectiveness of sewage disinfection in achieving this end is not readily demonstrable (27). In Europe, most countries do not routinely disinfect sewage effluent.

In England, the control of enteric disease is considered to be the best obtained by breaking the cycle of infection inherent in the water route by separation of the functions of sewage treatment and water supply and by stringent attention to the purification of potable waters (28). Water treatment plants are regarded as the prime barrier against the spread of waterborne disease, since well-operated water plants giving full treatment, can produce a pathogen-free water, irrespective of the pollution level of the source water.

From the point of view of recreational use, there is no statistically reliable epidemiological data to correlate microorganisms in bathing water with health risk, and the scientific basis for bacteriological limits in recreational water standards is not strong (27); the presence of microbes should not necessarily be equated with illness or the potential for illness (29). Although the necessity for efficient sewage treatment is not in question, in order to prevent eutrophication and maintain aesthetic quality, it is difficult to justify the disinfection of sewage effluent on the basis of the protection of public health. The non-disinfection of sewage effluents would not seem to be an unreasonable alternative to chlorination in many instances.

REFERENCES

1. Brungs, W.A. Effects of Residual Chlorine on Aquatic Life. J. WPCF, 45, 2180, 1973.

2. Brooks, A.J., and Baker, A.L. Chlorination at Power Plants: Impact on Phytoplankton Productivity, Science, 176, 1414, 1972.

3. Chlorine Task Force Report to International Joint Commission, December, 1976.

4. Zanoni, A.E. et al. An In situ Determination of the Disappearance of Coliforms in Lake Michigan. J. WPCF, 50, 321, 1978.

5. Geldreich, E.E. et al. The Bacteriological Aspects of Storm Water Pollution. J. WPCF, 40, 1861, 1968.

6. Sartor, J.C. et al. Water Pollution Aspects of Street Surface Contaminants. J. WPCF, 46, 458, 1974.

7. Dutka, B.J. Microbiological Study of Storm Water Run-off Waters from a 100% Residential Area. Can. Res. 10, 32, 1977.

8. Geldreich, E.E. Waterborne Pathogens. Water Pollution Microbiology, 207, ed. R. Mitchell, Wiley Interscience, 1972.

9. Wang, W.L., and Dunlop, S.G. Animal Parasites in Sewage and Irrigation Water. Sew. and Ind. Wastes, 26, 1020, 1954.

10. White, G.C. Disinfection Practices in the San Francisco Bay Area. J. WPCF, 46, 89, 1974.

11. Hendricks, C.W. Increased Recovery Rate of Salmonellae from Stream Bottom Sediments Versus Surface Waters. App. Microbiol., 21, 379, 1971.

12. Vanderpost, J.M., and Bell, J.B. Bacteriological Investigation of Alberta Meat-packing Plant Wastes with Emphasis on Salmonella Isolation, App. and Environ. Microbiol., 33, 538, 1977.

13. Hrubant, G.R. et al. Enterobacteria in Feedlot Waste and Run-off, App. Microbiol., 24, 378, 1972.

14. Dutka, B.J. et al. A bacteriological Study of the Rainy River. Rainy River and Lake of the Woods. International Joint Commission. Dept. Nat. Hlth. & Welfare (Can.). Div. of Pub. Hlth. Eng. Rep. KR-69-1, 1969.

15. Seyfreid, P.L. Incidence of Pseudomonas Aeruginosa in the Water of Swimming Pools and Public Beaches. Can. J. Pub. Hlth. 65, 55, 1974.

16. Dutka, B.J. et al. The Isolation of Salmonellae from the Bay of Quinte and the St. Lawrence River. 11th Conf. on Great Lakes Res. Milwaukee, Wisconsin. Dept. Nat. Hlth. and Welfare. (Can.). 1968.

17. England, B. et al. Virological Assessment of Sewage Treatment at Santee, California. Transmission of Viruses by the Water Route, 401. ed. G. Berg. New York, Interscience, 1967.

18. Nupen, E.M. The Isolation of Viruses from Sewage and Treated Sewage Effluents. Water Poll. Cont. 69, 430, 1970.

19. Lothrop, T.L. and Sproul, O.J. High-level Inactivation of Viruses in Wastewater by Chlorination. J. WPCF, 41, 567, 1969.

20. Gerba, C.P. et al. Viruses in Water: The Problem Some Solutions. Environ. Sci. and Tech. 9, 1122, 1975.

21. Subrahmanyan, T.P. Examination of Sewage and Sewage Sludge for Enteroviruses. Vols. 1 and 11. (Rep. #27 and 52). Training and Technology Transfer Div. Env. Protection Serv. Environment Canada, Ottawa, Ontario. 1977-78.

22. Sattar, S.A. Viral Pollution of the Ottawa River and its Possible Impact on the Quality of Potable and Recreational Waters in the Ottawa Area. Phase 1. Final Report for OME Res. Cont. #77-004-11. Dept. Microbiol. and Immunol. School of Medicine, University of Ottawa, May 1978.

23. Jeffrey, H.C., and Leach. R.M. Atlas of Medical Helminthology and Protozoology. Churchill Livingstone, London.

24. Shaw, P.K. et al. A Communitywide Outbreak of Giardiasis With Evidence of Transmission by a Water Supply. Ann. Int. Med. 87, 426, 1977.

25. Leibmann, H. Parasites in Sewage and the Possibility of Their Extinction. Adv. in Water Poll. Res., 269, Proc. 2nd Annual Conf. Tokyo, Pergamon Press, Oxford, 1964.

26. Kimer, J.C. et al. A Waterborne Outbreak of Giardiasis in Camas, Washington, J. AWWA, 70, 35, 1978.

27. Wastewater Disinfection in Canada. Water Pollution Control Directorate, EPS, Canada. Rep. #EPS 3-WP-78-4, May 1978.

28. Water Research Centre. England, Personal Communication.

29. Benarde, M.A. Land Disposal of Sewage Effluent; Appraisal of Health Effects of Pathogenic Organisms. J. AWWA, 65, 432, 1973.

TABLE 1 RECOVERY OF VIRUSES FROM SEWAGE TREATMENT PLANTS

SOURCE	PERCENT SAMPLES Positive
Influent	25-33 (100)
Primary settling tank	24
Activated sludge	11
Final settling	5-8
Final effluent	3* (54)
Activated sludge return	7
Raw sludge	11-38

* 0.5 ppm chlorine residual for 15 minutes at pH 7.2 → 7.5

From: Virus transmission by the water vehicle 11. Virus removal by sewage treatment procedures. Hlth. Lab. Sc. 3. 90. 1966. Page 99.

NB. The percentages in parenthesis are from ref. #22.

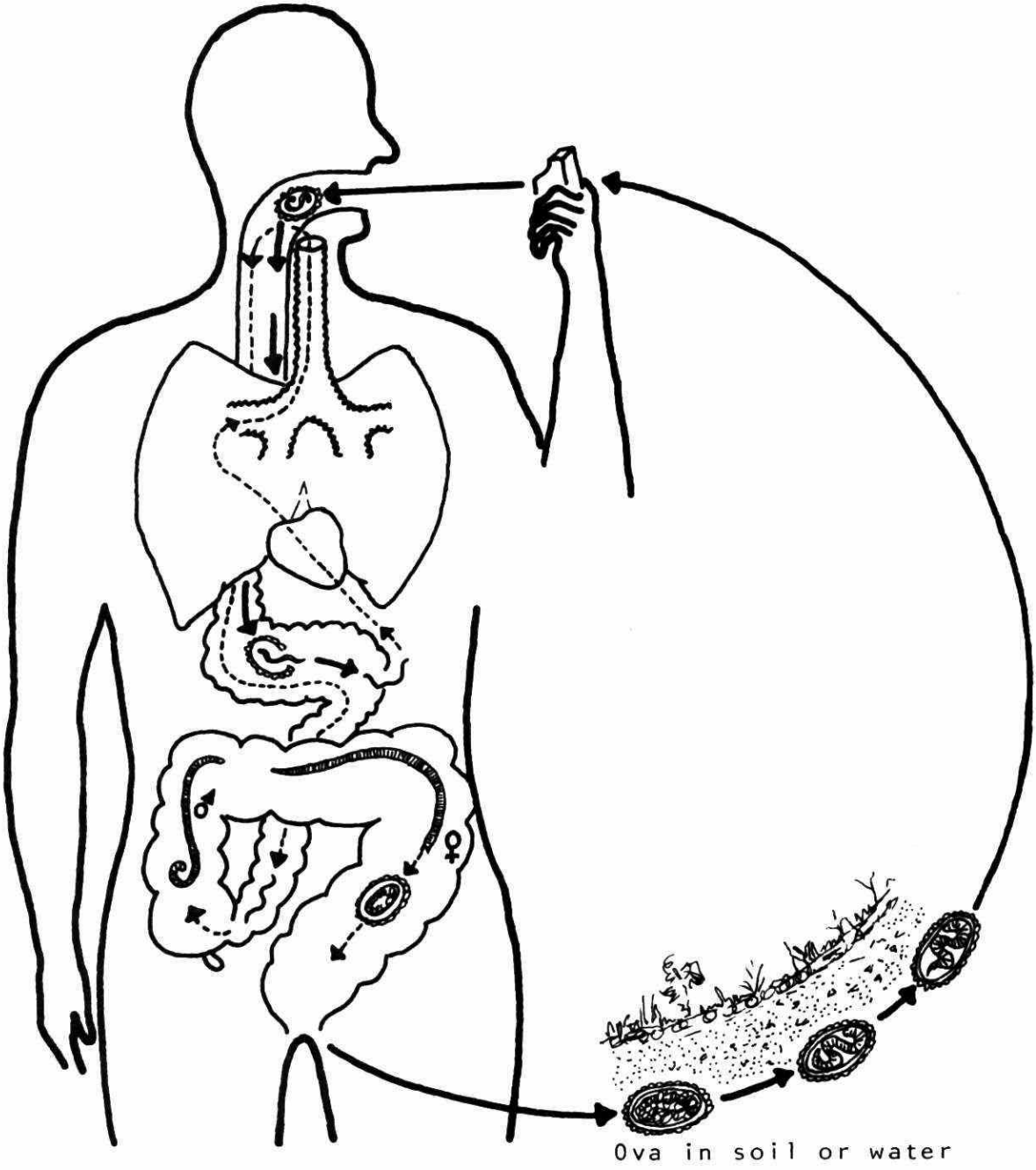
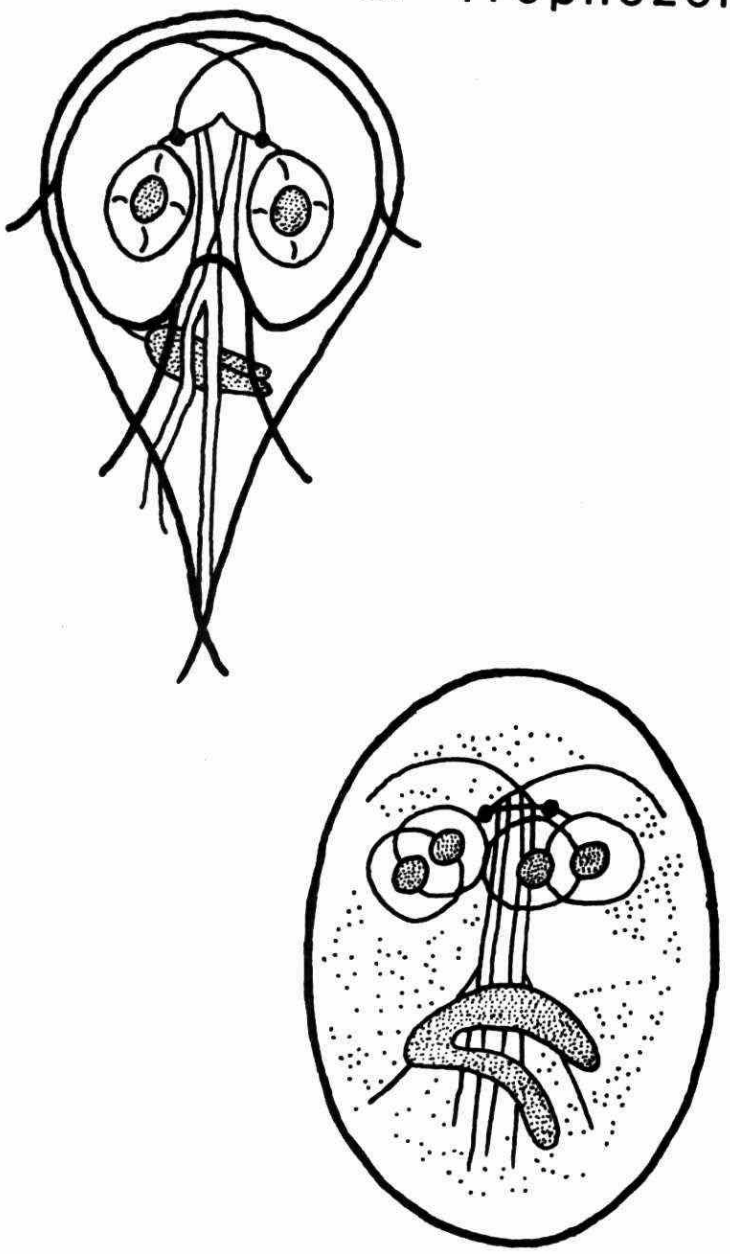


FIGURE 2 Life Cycle of Ascaris lumbricoides:

Larvae from ingested ova penetrate intestinal mucosa and migrate to lungs through heart, ascend through lungs, are swallowed and mature in intestine. Maturation cycle in man requires 2 months.

a. Trophozoite



b. Encysted form

FIGURE 3: Giardia lamblia:

The encysted form passes out of the infected individual (man or animal) with the feces

TD
172.5
.P65
1979

Proceedings of the seminar on
pollution control and
environmental health /
5109